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No. XV.

POCKET HANDBOOK

OF [illegible]

Useful + Information,

PRICE LISTS,

Telegraph + Code, + &c.,

RELATING TO

LEAD COVERED ELECTRIC CABLES, INSULATED WIRES, &c.,

WRITTEN AND COMPILED BY

JOSEPH + W. + MARSH.

PRESENTED BY THE

Standard Underground Cable Co.

PITTSBURGH, NEW YORK, CHICAGO.
ST. LOUIS.

JANUARY, 1897.

Entered according to Act. of Congress in the year 1897, by
JOSEPH W. MARSH,
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STANDARD

Underground Cable Co.

MANUFACTURERS OF

THE WARING CABLES

FOR

TELEGRAPH, TELEPHONE, ELECTRIC LIGHT AND POWER; UNDERGROUND, SUBMARINE AND AERIAL. INSULATED WIRE OF ALL KINDS; CABLE AND LINE WIRE ACCESSORIES.

GENERAL OFFICES: WESTINGHOUSE BUILDING, PITTSBURGH, PA.

BRANCH OFFICES:

NEW YORK, 18 Cortlandt St., G. L. WILEY, Manager.
" WIRE DEPT., T. E. HUGHES, Manager.
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P. H. W. SMITH.

General Superintendent Construction,
Manager Conduit Department,
F. S. VIELÉ.

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PREFACE.

The edition of 8,000 copies of our No. XI pocket handbook, issued in 1890, has long since been exhausted, and numberless requests for additional copies, as well as direct testimonials as to the value of the book, from those whose business it is to design, construct, or operate electrical plants of all kinds, have led us to issue the present volume in a still more complete form.

The purpose kept in mind in preparing this revised edition has been to give all useful information relating to electric wires and cables, and the installation of the latter, in as brief a form as possible, consistent with a proper understanding of the subject discussed, and also to provide convenient rules, tables, etc., for ready reference and use by practical men.

We cheerfully acknowledge the valuable suggestions received from many prominent engineers, superintendents and managers, who have kindly responded to the request made in the former edition, to co-operate with us in making this book as useful as possible to the electrical public, and we now renew the request.

We were the pioneers of the underground cable business, and for a number of years the only distinctively underground cable company in the United States; it is, therefore, but natural that we should have acquired more valuable experience in this line than anyone else, and this experience we cheerfully place at the service of our customers.

Since the last handbook was issued in 1890 our manufacturing facilities have been greatly increased, including a complete modern plant for the manufacture of rubber covered wires and cables, so that we can now furnish our customers any kind of wire or cable that they may desire, whether insulated with fibre, paper or rubber. Our extensive factories are located in the City of Pittsburgh, and prompt delivery can be made to all parts of the country.

Our products have been installed and successfully operated in every State in the Union, and in many foreign countries, notably, Venezuela, Brazil, Argentine Republic, England, India, Australia, China and Japan. Our processes of manufacture are reduced to as exact a science as is that of making steel rails or "I" beams, and we expect to continue to merit the confidence of buyers and users of the product covered by our lists.

It is hoped that this book will prove eminently useful, and that an acknowledgement of its receipt will be sent to the

STANDARD UNDERGROUND CABLE COMPANY,

Westinghouse Bldg., Pittsburgh, Pa.

JANUARY, 1897.

GENERAL DIRECTIONS TO PURCHASERS.

In order to avoid delays and misunderstandings, purchasers should carefully note the following:

1st. All price lists and discounts heretofore issued are hereby cancelled. The Telegraph Code in Handbook No. 11 is now superseded by the code herein provided.

2nd. All prices are subject to change without notice.

3rd. Prices are F. O. B. cars at Pittsburgh, unless otherwise specified.

4th. Our reels or packages will be credited at price charged, if returned in good order, freight prepaid; if slats are not returned a deduction will be made. In order to secure the specially low freight rate on empty reels, they must be returned by the same road or roads over which they were received and must be billed as "empty reels returning, having been shipped over the road filled."

5th. Terms, cash in 30 days from date of invoice, or one per cent. off for cash in ten days. Interest will be added on all overdue accounts.

6th. In sending a first order, if credit is desired, references should be given, as otherwise the order may be delayed.

7th. Unless the wire gauge is mentioned, all orders will be entered as "Brown & Sharpe's Gauge."

8th. All orders should be explicit as to gauge, size, quantity and grade.

9th. All orders should state whether the shipment is to be made by freight or express and should also name the route; in absence of instructions shipments will be made by fastest freight route.

10th. No claims for allowances will be entertained, unless made within five days after delivery of the goods.

PRICE LISTS

OF

Insulated Wires,

Electric Cables

AND

Accessories.

LETTERS PATENT.

NOTICE.

This Company owns over one hundred patents, and pending applications (United States, over 78; Canada, 22) relating to its manufactures and methods, notices and dates of which will be found on the respective articles to which they apply, or on the packages containing the same.

All infringers will be vigorously prosecuted.

Standard Underground Cable Company.

TRADE MARKS.

"WARING." "OZITE." "TIP TOP."
"STERLING." "STANDARD."

(See also figures 40, 41, 42 and 43.)

DUPLEX WIRE.

MARSH DUPLEX OR ANTI-INDUCTION WIRE.

For Telephone, Telegraph or Electric Light Circuits.
(For descriptive matter see page 57.)

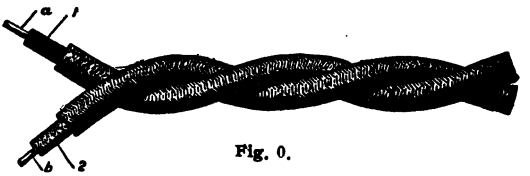


Fig. 0.

B. & S. G.	Diameter over Braid Single Wire.	Price per Ft. Two Wires. Cents.	Telegraph Code.
20	181	2.50	cannibal.
18	146	3.00	cannon.
16	176	4.00	cannonade.
14	187	5.00	cannular.
12	250	6.50	canny.

DUPLEX RUBBER INSULATED WIRE.

(For descriptive matter see page 57.)

Two Rubber Insulated and Braided Wires Twisted Together.

B. & S. G.	Diameter over Braid Single Wire.	Price per Ft. Two Wires. Cents.	Telegraph Code.
20	181	3.50	canoes.
18	181	4.00	canoeing.
16	156	5.50	canons.
14	187	7.00	canoness.
12	250	9.00	canonic.

ELECTROLIER WIRE. TAPED FLAT.

Light "TIP TOP" Insulation. See page 12.
Special thickness of Insulation to order.
(For descriptive matter see page 57.)

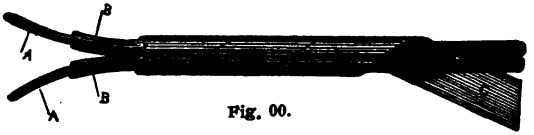
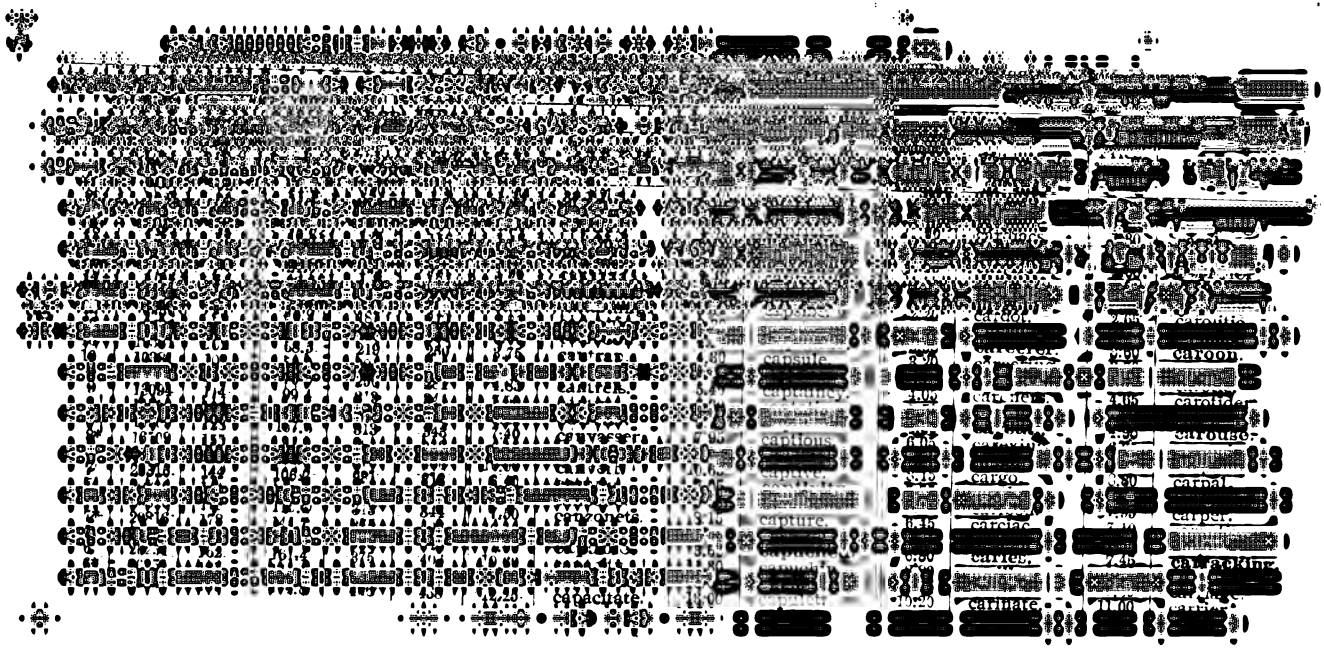
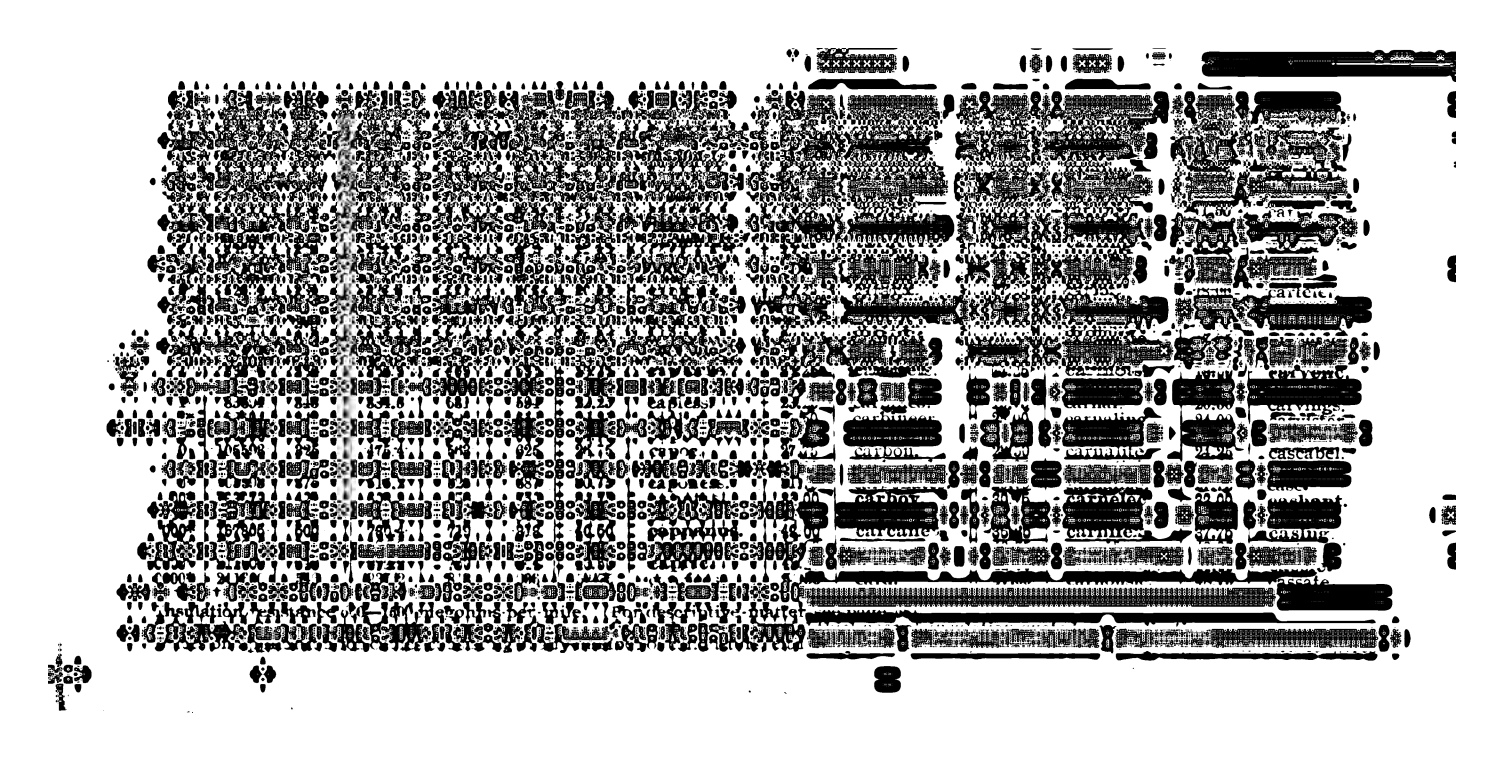


Fig. 00.

B. & S. G.	Diameter Mils over both Wires and Tape	Price per Ft. Two Wires. Cents.	Telegraph Code.
20	231	3.20	canonist.
18	231	3.60	canonize.
16	281	5.00	canonry.
14	343	7.00	canopy.
12	407	9.50	canorous.

Our Weatherproof, W. A. C., "Tip Top" or Underwriters' Wire, either twisted together or laid parallel and braided flat, will be furnished at a slight advance over the price per foot or pound of the wire itself. In telegraphing an order for Duplex Wire of these grades, write first the code word for the kind and size of wire, then (if desired flexible) the code word "defyers," and then the code word "pullet."


capsule.
capture.
captions.
capture.
caracole.
caroon.
carouse.
carpal.
carpel.
carpaking.


carbon
carbox
carcane
carmine
cascabel
casing

"OZITE," OR

[TRADE MARK]

WARING INSULATING COMPOUND.

(For descriptive matter see page 76.)

For Filling Cable Joints, Cable Terminals, Junction Boxes, Converters, Etc.

In ordering, state purpose for which the Compound is to be used. The right is reserved to decline filling any or all orders for this Compound.

	Price per Gallon.	Telegraph Code.
Waring Compound in 1 gal. cans,....	$1.00	chack.
" " " 2 " "	.95	chad.
" " " 5 " "	.90	chafe.
" " " approximately		
50 gal. barrels,.....	.80	chaffic.

GALVANIZED IRON AND STEEL WIRE.

Telephone and Telegraph.

(For descriptive matter see page 59.)

B.W.G.	Wt. per Mile.	Price per Pound.	Telegraph Code. B. B.	Telegraph Code. E. B. B.	Telegraph Code. Steel.
4	730	Price on all grades quoted on application.	chaffy.	chamfer.	chaplet.
6	540		chainey.	chamois.	chapter.
8	380		chair.	champ.	charity.
9	320		chaise.	champion.	charmer.
10	260		chalaze.	chancel.	charnel.
11	214		chaldese.	chaos.	charon.
12	165		chalice.	chapel.	charted.
14	96		challis.	chaperon.	charts.

GALVANIZED STEEL WIRE STRAND.

For Suspension, Guy, Span Wire, Etc.

This strand is composed of seven wires twisted together.

(For descriptive matter see page 59.)

Approx. Diam., Strand.	Size of Wires I. W. G.	Price 100 Feet. Cents.	Wt. per 100 Feet.	Tensile Strength in Pounds.	Telegraph Code.
½	8	240	52	8320	chase.
15/32	9	205	42	6720	chasers.
7/16	10	180	36	5720	chaste.
3/8	11	150	29	4640	chastely.
11/32	12	115	21	3360	chastise.
5/16	13	90	16	2560	chastity.
9/32	14	70	12	1920	chateau.
¼	15	60	10	1600	chattel.
7/32	16	55	8	1280	chaucer.
3/16	17	42	6	960	cheater.
11/64	18	38	4.3	688	cheating.
5/64	19	35	3.3	528	checkmate.
1/8	20	30	2.4	384	cheeky.
3/32	21	28	2	320	cheeping.

BARE WIRE FOR ELECTRICAL PURPOSES.

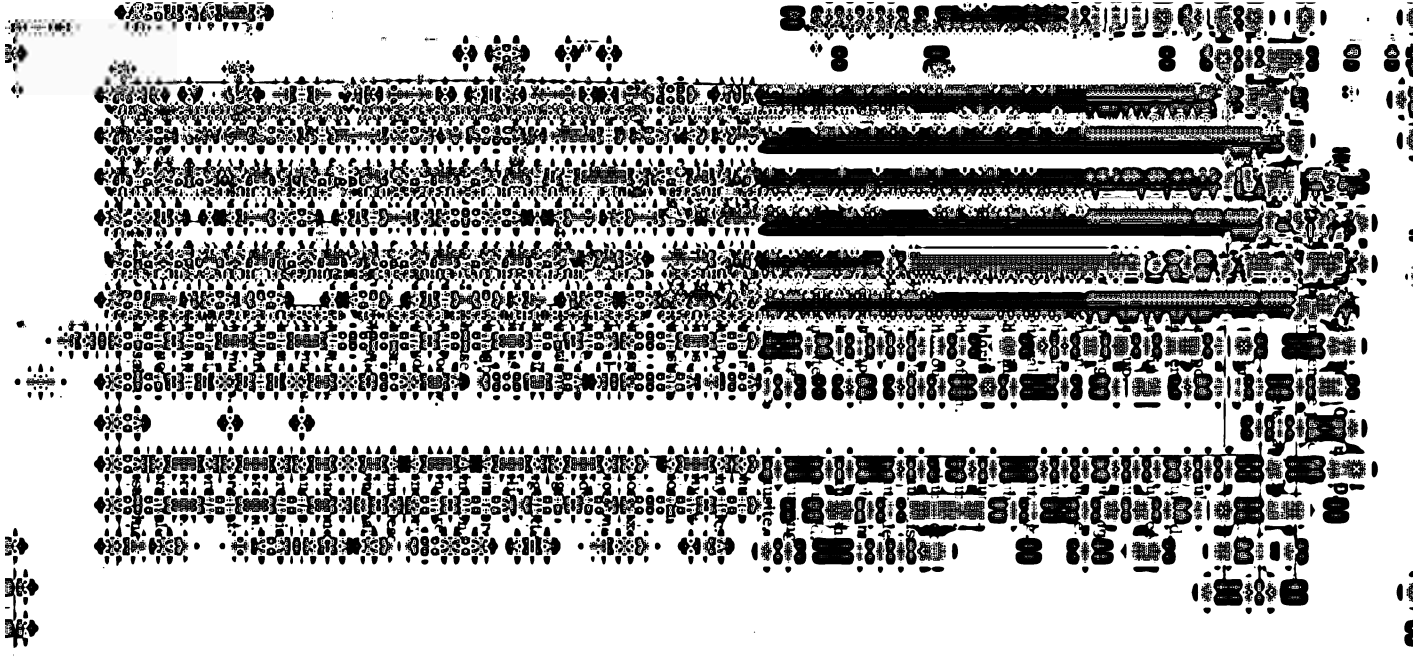
(For Descriptive Matter, see page 59.)

B. & S. G. No.	Pure Copper. Pounds per 1000 Feet.	Pure Copper. Price per Pound.	German Silver Resistance Wire, per Pound.	Telegraph Code. Pure Copper. * Soft Drawn.	Telegraph Code. German Silver. ‖
0000	639.33	19c	.....	cheer. ¶	.....
000	507.01	19	.....	cheese.	.....
00	402.09	19	.....	cheetah.	.....
0	319.04	19	.....	chemist.	.....
1	252.88	19	.....	chenille.	.....
2	200.54	19	.....	cherish.	.....
3	159.08	19	.....	cherry.	.....
4	126.12	19	.....	chert.	.....
5	100.01	19	.....	cherub.	.....
6	79.32	19	.....	chess.	.....
7	62.90	19	.....	chessom.	.....
8	49.88	19	.....	chester.	.....
a 9	39.56	19⅛	.....	chestnut.	.....
10	31.37	19⅛	.....	cheston.	.....
11	24.88	19¼	18 Per Cent. Wire.	chevel.	.....
12	19.73	19¼		chevron.	.....
13	15.65	19⅜		chevy.	.....
14	12.41	19¾	78c	chew.	chimpanzee.
15	9.84	20	78	chibouk.	china.
16	7.81	20¼	78	chicane.	chinaman.
17	6.19	20½	80	chick.	chinarose.
18	4.91	21	80	chicken.	chinaware.
19	3.78	21¼	83	chickpea.	chincapin.
20	3.09	21¾	83	chickory.	chinchilla.
21	2.45	22	95	chider.	chine.
22	1.94	22¾	98	chiding.	chinese.
23	1.54	40	$1.03	chiefdom.	chingly.
24	1.22	43	1.08	chiefess.	chinks.
25	.97	46	1.08	chieftain.	chinky.
26	.77	54	1.14	chievance.	chinned.
27	.61	62	1.25	chieve.	chinning.
28	.48	67	1.40	chigoe.	chintz.
29	.38	73	1.55	chilblain.	chip.
30	.30	82	1.75	child.	chipax.
b 31	.24	95	1.95	childbirth.	chiphat.
32	.19	$1.30	2.35	childed.	chipmunk.
33	.15	1.50	2.60	childish.	chippings.
34	.12	1.70	2.95	children.	chippy.
35	.10	2.00	3.65	chiliad.	chirking.
36	.08	3.25	6.50	chilling.	chirm.
37	.06	5.75	11.50	chilly.	chirograph.
38	.05	10.00	18.00	chimb.	chiroplast.
39	.04	15.00	.....	chimer.	.....
40	.03	20.00	.....	chimney.	.....

* Hard drawn copper wire furnished at same price.

¶ In telegraphing for hard drawn copper wire, add the syllable "hard" to the code word above for pure copper.

‖ If the German Silver Wire is desired insulated with one or two wraps of cotton or silk, see Telegraph Code, page 45.



MAGNET WIRE. SILK COVERED

(For descriptive matter see page 60.)

	B. & S. G. No.	Price per Lb.		Telegraph Code.	
		Single.	Double.	Single.	Double.
b	16	$ 1.12	$ 1.53	cisco.	clabber.
	17	1.12	1.53	cistercian.	clachan.
	18	1.15	1.57	cisterns.	clack.
	19	1.15	1.57	cistic.	clacker.
	20	1.18	1.61	cistus.	clackbox.
	21	1.20	1.63	citadel.	clackdish.
	22	1.30	1.76	citator.	clamber.
	23	1.42	1.93	cithera.	clammy.
	24	1.56	2.13	citicism.	clamor.
	25	1.81	2.48	citigrade.	clan.
	26	2.10	2.88	citizen.	clangor.
	27	2.25	3.07	citole.	clangous.
	28	2.38	3.23	citrate.	clanking.
	29	2.75	3.76	citric.	clannish.
	30	2.95	4.02	citrine.	clanship.
	31	3.25	4.40	citron.	clansman.
c	32	3.45	4.53	citrus.	clapboard.
	33	3.90	5.10	cittern.	clapnet.
	34	4.10	5.30	civet.	clapper.
	35	5.85	7.78	civic.	clarence.
	36	7.00	8.88	civilian.	claret.
	37	11.00	13.63	civilist.	clarichord.
	38	13.00	14.50	civilize.	clarifier.
	39	15.00	18.00	civilly.	clarify.
	40	20.00	23.00	civism.	clarifying.

INCANDESCENT LAMP CORD.

(For descriptive matter see page 61.)

Insulation.	B.&S. G. No.	Cents per Yard.		Telegraph Code.	
		Silk Braided.	Cotton Braided.	Silk Braided.	Cotton Braided.
OZITE.	12	22c	18c	clarigate.	clausure.
	14	19	15	clarigating.	clavate.
	16	12	8	clarigation.	clavating.
	18	10	6	clarinet.	clavel.
	20	6.5	4.5	clarion.	claverer.
	22	6.5	4.5	clarionets.	clavering.
SHEET RUBBER.	12	40	32	claritude.	claviary.
	14	29	21	clarying.	clavichord.
	16	19	12	clashing.	clavicle.
	18	16	9	clasp.	clavier.
	20	12	7	clasper.	claviform.
	22	12	7	classible.	claviger.
BALATA.	12	39	34	classic.	clavis.
	14	33	27	classical.	clawed.
	16	24	21	classicist.	clawless.
	18	18	15	classific.	claws.
	20	11	10	classman.	clayish.
	22	9	8	classmate.	claymore.
HIGH GRADE SEAMLESS RUBBER.	12	50	43	clatters.	cleaning.
	14	45	40	clatterings.	cleanly.
	16	30	27	claudent.	cleanness.
	18	22	20	claudicant.	cleanser.
	20	15	13	claustral.	clearances.
	22	12	10.5	clausular.	clearing.

(For Telegraph Code to designate colors see page 11.)

ANNUNCIATOR WIRE.

(For descriptive matter see page 62.)

B. & S. G. No.	Approximate Length per Pound.	Price per Pound.	Telegraph Code.
12	40 ft.	23	cleave.
14	60	24.5	cleaving.
16	105	26	cledge.
18	150	27.5	clef.
20	225	29.5	clematis.
22	250	32.5	clement.

OFFICE WIRE.

(For descriptive matter see page 63.)

B. & S. G. No.	Approximate Length per Pound.	Price per Pound.	Telegraph Code.
12	35 ft.	23.5	clench.
14	55	25	clepe.
16	95	26.5	clergy.
18	135	28	cleric.
20	155	30	clerkly.
22	200	33	clever.
Ozite or Waring Insulation inside, 2 cts. per pound extra.			cleverly.

OFFICE CABLES.

(For descriptive matter see page 63.)

B. & S. G. No.	Ordinary Finish.	Ozite Finish.	Telegraph Code.	
			Ordinary Finish.	Ozite Finish.
12	25.5	27.5	clevis.	clientage.
14	27	29	clevy.	cliental.
16	28.5	30.5	clue.	clienteled.
18	30	32	click.	clientele.
20	32	34	clicker.	cliffy.
22	35	37	cliency.	clift.

UNDERWRITERS' WIRE.

(For descriptive matter see page 63.)

B. & S. G. No.	Approx. ft. per Pound.	Approx. lbs. per 1000 ft.	Cents per Pound.	Telegraph Code.
0000	1.42	701	20	clifted.
000	1.77	565	20	climatal.
00	2.22	450	20	climate.
0	2.75	365	20	climax.
1	3.42	292	20	clincher.
2	4.14	241	20	cling.
3	5.40	185	20	clinic.
4	6.76	148	20	clinker.
5	8.32	121	20	clinoid.
6	10.20	98	20	clio.
7	12.50	80	20	clipper.
8	14.70	68	20	clipping.
9	18.50	54	21	cloaca.
10	22.22	45	21	cloak.
12	31.24	32	22	cloaking.
14	45.45	22	23.5	clod.
16	66.66	15	25	clodpate.
18	83.33	12	26.5	clodpoll.
19	100.00	10	28.5	cloggy.
20	125.00	8	28.5	cloister.

B. & S. G.	Cents per lb. either grade.	"Sterling." (Double Covered.) Lbs. per mile.	Lbs. per 1000 ft.	Diam. in Mils.	Telegraph Code.	"Standard." (Triple Covered.) Lbs. per mile.	Lbs. per 1000 ft.	Diam. in Mils.	Telegraph Code.	"Tip Top." (Specially High Grade Insulation. Lbs. per mile.	Lbs. per 1000 ft.	Diam. in Mils.	Telegraph Code.
0000	20c	3690	699	725	cloisteral.	3910	741	780	cloom.	4135	783	835	cloomac.
000	20	2970	562	655	cloisterboy.	3160	598	700	cloopy.	3360	655	765	cloopyac.
00	20	2390	452	585	cloistered.	2560	485	635	closeness.	2740	519	700	closenessac.
0	20	1860	352	545	cloistering.	2020	382	590	closet.	2190	415	655	closetac.
1	**20**	**1500**	**284**	**505**	**cloisterman.**	**1650**	**312**	**550**	**closure.**	**1800**	**341**	**610**	**closureac.**
2	20	1225	232	470	cloistrally.	1340	254	515	clothes.	1460	276	570	clothesac.
3	20	980	186	385	cloistress.	1050	199	450	clothier.	1130	214	505	clothierac.
4	20	800	151	360	cloistron.	860	163	430	clothing.	925	175	475	clothingac.
5	20	640	121	335	cloker.	700	132	400	clotter.	765	145	455	clotterac.
6	**20**	**520**	**98**	**300**	**clokester.**	**575**	**109**	**360**	**cloudage.**	**625**	**118**	**420**	**cloudageac.**
7	20	420	79	270	clomb.	465	88	335	cloudily.	515	98	390	cloudilyac.
8	20	345	65	245	clongs.	390	74	265	cloudless.	435	82	320	cloudlessac.
9	21	275	52	225	clohen.	320	60	255	clout.	360	68	295	cloutac.
10	21	235	45	195	clohis.	265	50	220	clovate.	295	56	265	clovateac.
11	**22**	**190**	**36**	**180**	**cloit.**	**225**	**42**	**205**	**clove.**	**255**	**48**	**245**	**cloveac.**
12	22	145	27	165	clokus.	180	31	185	clown.	215	41	230	clownac.
14	23.5	105	20	140	clolur.	130	24	160	club.	160	30	205	clubac.
16	25	80	15	130	clomut.	100	19	150	clubman.	120	23	190	clubmanac.
18	26.5	55	10	125	clonat.	80	15	145	clubmens.	105	20	185	clubmensac.
20	**28.5**	**42**	**8**	**122**	**clonos.**	**68**	**12**	**135**	**clubmint.**	**84**	**16**	**180**	**clubmintac.**

WEATHERPROOF LINE AND HOUSE WIRE. (For

B. & S. G.	Cents per lb. either grade.	"Sterling." (Double Covered.) Lbs. per mile.	Lbs. per 1000 ft.	Diam. in Mils.	Telegraph Code.	"Stand (Triple C Lbs. per mile.	Lbs. per 1000 ft.	Dia in Mil
0000	20c	3690	699	725	cloisteral.	3910	741	78
000	20	2970	562	655	cloisterboy.	3160	598	70
00	20	2390	452	585	cloistered.	2560	485	63
0	20	1860	352	515	cloistering.	2020	382	59
1	20	1500	284	505	cloisterman.	1650	312	55
2	20	1225	232	470	cloistrally.	1340	254	51
3	20	980	186	385	cloistress.	1050	199	45
4	20	800	151	360	cloistron.	860	163	43
5	20	640	121	335	cloker.	700	132	4(
6	20	520	98	300	clokester.	575	109	3(
7	20	420	79	270	clomb.	465	88	3
8	20	345	65	245	clongs.	390	74	2(
9	21	275	52	225	clohen.	320	60	2
10	21	235	45	195	clohis.	265	50	2
11	22	190	36	180	cloit.	225	42	2
12	22	145	27	165	clokus.	180	34	1
14	23.5	105	20	140	clolur.	130	24	1
16	25	80	15	130	clomut.	100	19	1
18	26.5	55	10	125	clonat.	80	15	1
20	28.5	42	8	122	clonos.	68	12	1

WEATHER-PROOF GALVANIZED IRON AND STEEL WIRE. TELEPHONE AND TELEGRAPH.

(For descriptive matter, see page 69.)

B. W. Gauge		Price per Mile.			Telegraph Code.		
		BB.	EBB.	Steel.	BB.	EBB.	Steel.
Double Covered.	4	$60.00	$65.00	$60.00	clubmoss.	clubrushil.	cluering.
	6	52.00	56.00	52.00	clubmossac.	clubrushon.	clueron.
	8	44.00	47.00	44.00	clubmosser.	clubrushut.	cluerurs.
	9	41.00	43.00	41.00	clubmossil.	cluck.	clump.
	10	37.00	39.00	37.00	clubmosson.	clucker.	clumpate.
	11	33.00	35.00	33.00	clubmossut.	cluckerac.	clumper.
	12	30.00	32.00	30 00	clubroom.	cluckeres.	clumperac.
	14	28.00	29.00	28.00	clubroomac.	cluckeril.	clumperil.
Triple Covered.	4	65.00	70.00	65.00	clubroomer.	cluckeron.	clumperon.
	6	56.00	60.00	56.00	clubrooms.	cluckerur.	clumperur.
	8	47.00	50.00	47.00	clubroomil.	clucking.	clumping.
	9	44.00	46.00	44.00	clubroomon.	clue.	clumpurt.
	10	40.00	42.00	40.00	clubroomut.	cluerac.	clumsier.
	11	36.00	38.00	36.00	clubrush.	cluerate.	clumsil.
	12	33.00	35.00	33.00	clubrushac.	cluers.	clumsiness.
	14	31.00	32.00	31.00	clubrusher.	clueril.	clumsy.

WEATHER-PROOF CABLES.

MADE OF A SUITABLE NUMBER OF SMALLER WIRES

(For descriptive matter, see page 64.)

Size. B. & S. G. and Circ. Mils.	Diameter Mils.		Approx. Weight, per 1000 feet.		Price per lb.	Telegraph Code.	
	Double.	Triple.	Double.	Triple.		Double.	Triple.
18	154	185	11	17	26	cluniac.	clutch.
16	169	200	16	21	26	cluniacer.	clutchac.
14	184	215	22	26	24	cluniacil.	clutchate.
12	199	230	29	37	24	cluniacon.	clutcher.
10	219	250	49	55	22½	cluniacurt.	clutcheril.
9	234	265	56	66	22½	clusia.	clutching.
8	254	285	70	81	21½	clusialic.	clutchon.
7	299	330	85	97	21½	clusiaser.	clutchurs.
6	339	370	106	121	21½	clusiatil.	clutter.
5	354	385	131	145	21	clusiaton.	clutterac.
4	374	405	163	179	21	clusiatur.	clutterate.
3	394	425	201	219	21	clunch.	clutterers.
2	474	505	250	279	21	cluncher.	clutteril.
1	559	590	307	343	21	cluncherac.	cluttering.
0	659	690	380	420	21	clunchil.	clutteron.
00	719	750	488	533	21	clunchilic.	clypeate.
000	759	810	608	658	21	clunching.	clypeatac.
0000	779	890	755	815	21	clunchon.	clypeater.
250000	859	906	854	928	21	clunchurt.	clypeatil.
300000	890	937	994	1080	21	clung.	clypeating.
350000	921	968	1159	1260	21	clungate.	clypeaton.
400000	953	1000	1324	1439	21	clunger.	clysmian.
450000	1016	1063	1515	1647	21	clungerac.	clysmianac.
500000	1078	1125	1706	1854	21	clungeron.	clysmianer.
550000	1109	1156	1840	2000	21	clungerts.	clysmianil.
600000	1141	1188	2021	2197	21	clungerur.	clysmic.
650000	1203	1250	2173	2362	21	clunging.	clysmical.
700000	1234	1281	2343	2547	21	cluster.	clysmicers.
750000	1266	1313	2511	2729	21	clusterac.	clysmicing.
800000	1328	1375	2677	2910	21	clusterer.	clysmicon.
850000	1359	1406	2845	3092	21	clusteril	clysta
900000	1391	1438	3010	3272	21	clustering.	clystaer.
950000	1421	1468	3178	8454	21	clusteron.	clystaerac.
1000000	1484	1531	3310	3598	21	clustronic.	clystaeril.

W. A. C. FIRE AND MOISTURE WIRE. DRAB EXTERIOR.

(For descriptive matter see page 70.)

B. & S. G. No.	Approx. pounds per 1000 ft.	Approx. Diam. Mils.	Cents per Foot.	Telegraph Code.
0000	759	850	32.5	clyster.
000	657	750	28	clysterize.
00	526	675	22.5	coach.
0	403	645	17.2	coachbox.
1	342	565	14.5	coachman.
2	275	540	11.7	coadjutor.
3	218	485	9.3	coagent.
4	177	460	7.6	coagulate.
5	145	430	6.2	coal.
6	124	385	5.3	coalesce.
7	107	360	4.6	coalfield.
8	77	325	3.3	coalfish.
9	67	305	3.1	coalpit.
10	54	295	2.5	coaster.
12	38	265	2.0	coasting.
14	31	240	1.7	coastline.
16	28	230	1.7	coastwise.
18	25	220	1.6	coat.
20	20	215	1.4	coatarm.

Solid conductor will be furnished unless otherwise specified.

"TIP-TOP" FIRE & WATER-PROOF WIRE. DRAB EXTERIOR.

(For descriptive matter see page 70.)

	B. & S. G. No.	Approx. pounds per 1000 ft.	Approx. Diam. Mils.	Cents per Foot.	Telegraph Code.
Flexib.	0000	820	750	42	coatband.
Flexib.	000	665	700	36	coatbraid
Flexib.	00	540	625	29	coatbutton.
Flexib.	0	445	575	25	coatcanvas.
	1	375	485	20	coatcard.
	2	300	450	16.5	coatful.
	3	250	420	13	coathook.
	4	205	385	10	coating.
	5	168	360	8	coatiron.
	6	159	335	7.5	coatless.
	7	116	315	6.8	coatlining.
	8	97	295	5.7	coatmaker.
	9	82	280	5	coatrack.
	10	70	265	4.3	coatsleeve.
	12	52	240	3.2	coattail
	14	38	220	3.15	coax.
	16	28	205	2.8	coaxer.
	18	20	190	2.2	coaxing.
	20	15	180	2.0	coaxingly.

If flexible conductor is desired, see pages 14 and 21.

Figure 1. No. 0. B. & S. G.

FIRE PROOF HOUSE WIRES, WITH HIGH INSULATION.

WARING ELECTRIC LIGHT AND POWER CABLES

FOR LOW TENSION CURRENTS.

STANDARD LEAD AND STANDARD FIBER INSULATION.

B. & S. G. No.	Area Circul'r Mils.	Nearest Approx. Birm'am Wire Gauge No.	Thickness of Insulation Mils.	Approx. Diam. of Cable Mils.	Approx. Pounds per 1000 Feet.	Cents per foot of one-Cond'r Cable.	Telegraph Code.
20	1021	21—	16	145	69	3.0	cob.
19	1252	20+	16	150	78	3.0	cobalt.
18	1624	19+	31	180	98	3.45	cobbing.
17	2048	18½+	31	185	108	3.90	cobbler.
16	2586	18+	38	235	170	4.2	cobloaf.
15	3257	17—	38	240	180	4.8	cobnut.
14	4107	16—	47	270	212	5.4	cobra.
13	5178	15	47	275	222	6.0	cobweb.
12	6530	14—	47	300	270	7.2	coca.
11	8234	13½+	47	310	290	7.95	cockade.
10	10381	12½+	63	365	345	9 0	cockal.
9	13094	11½+	63	380	390	10.2	cockeye.
8	16509	10½+	70	425	540	12.0	cockle.
7	20816	9—	94	490	685	15.0	cockpit.
6	26250	8—	94	565	818	17.7	cocoon.
5	33102	7—	94	595	891	19.5	coction.
4	41742	6+	94	625	969	21.75	coddle.
3	52634	4—	94	655	1053	24.3	codetta.
2	66373	3—	94	690	1146	27.5	codex.
1	83694	2+	94	720	1251	31.5	codfish.
0	105592	0½+	94	815	1772	40.5	codger.
00	133079	00½+	94	860	1911	46.5	codicil.
000	167805	000½+	94	940	2194	54.0	codify.
0000	211600	0000+	94	985	2410	63.0	codilla.
.....	250000	.....	94	1030	2611	71.0	codist.
.....	300000	.....	94	1085	2857	80.0	coehorn.
.....	350000	.....	94	1095	3083	90.0	coequal.
.....	400000	.....	94	1125	3306	100.0	coerce.
.....	450000	.....	94	1190	3563	109.0	coeval.
.....	500000	.....	94	1220	3820	118.5	coexist.
.....	550000	.....	94	1250	4075	129.0	coexistence.
.....	600000	.....	94	1315	4333	138.0	coexistent.
.....	650000	.....	94	1375	4575	148.0	coexister.
.....	700000	.....	94	1410	4818	158.0	coexisting.
.....	750000	.....	94	1440	5065	168.0	coexpand.
.....	800000	.....	94	1470	5300	177.0	coexpandence.
.....	850000	.....	94	1530	5539	187.5	coexpandent.
.....	900000	.....	94	1565	5779	198.0	coexpanding.
.....	950000	.....	94	1595	6017	207.0	coexpander.
.....	1000000	.....	94	1625	6262	216.0	coexpansion.

See page 24 and 25 for List Prices of Cables with 4-32, 5-32 and 6-32 insulation; see pages 26, 27 and 83 for illustrations and important information.

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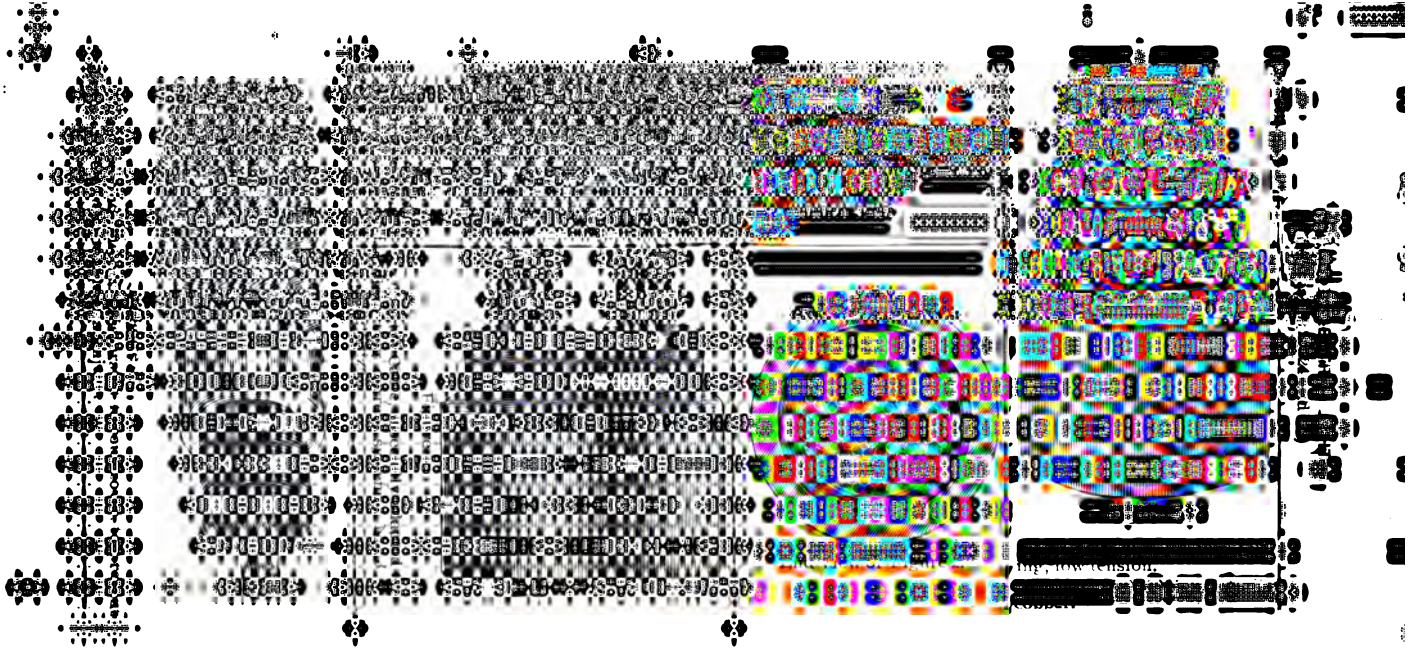
WARING ELECTRIC LIGHT AND POWER CABLES.

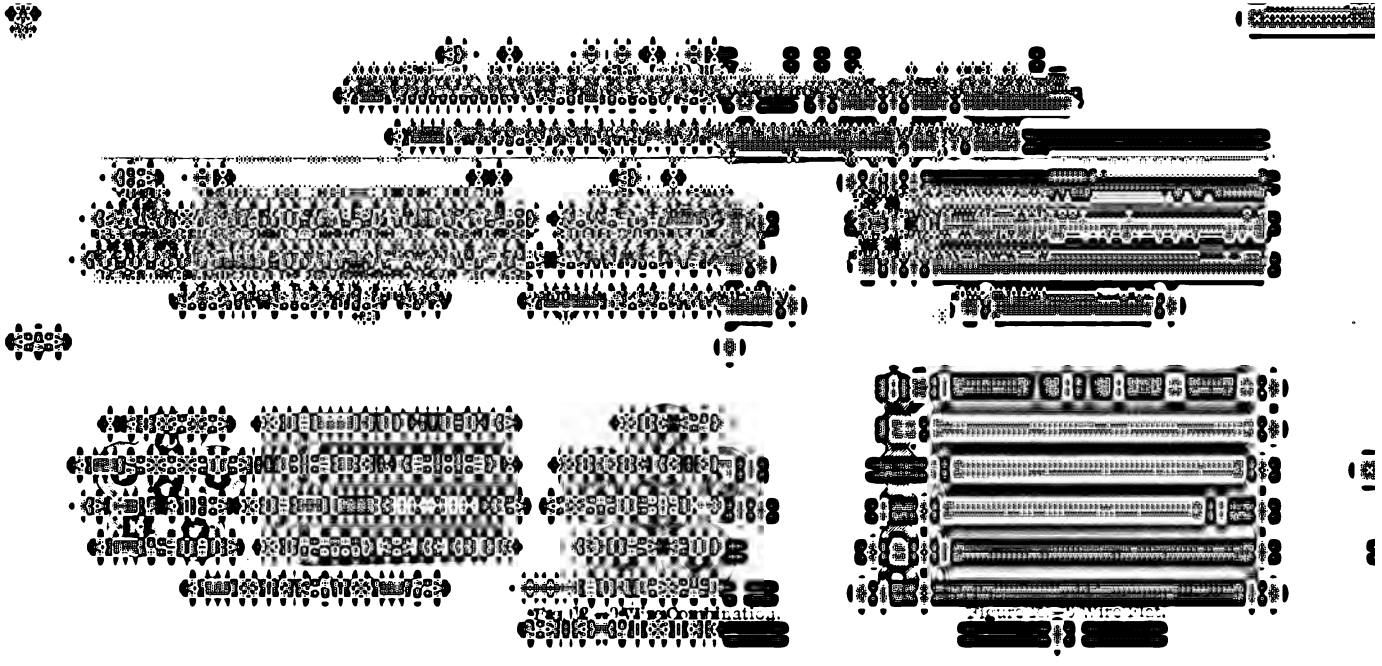
STANDARD LEAD, PAPER OR FIBER INSULATION PROPORTIONAL TO VOLTAGE.

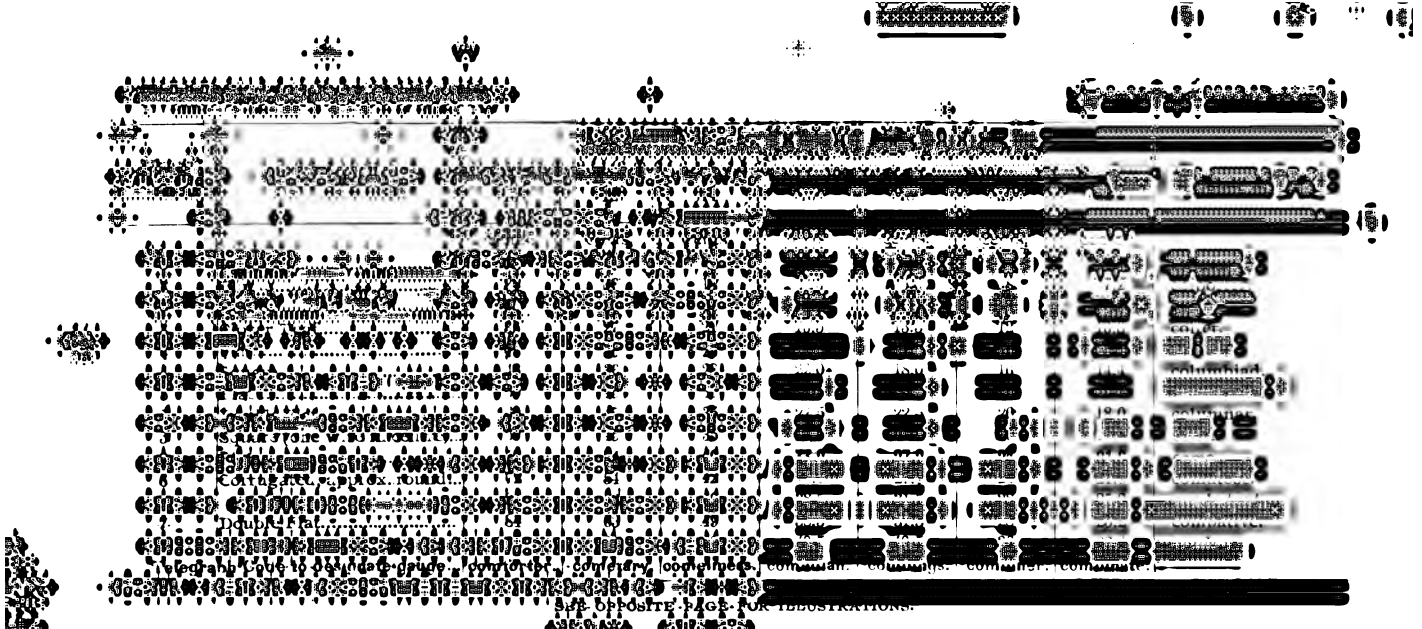
Copper Conductor.			1-8 Inch Insulation, for 400 to 900 Volts.				5-32 Inch Insulation, for 1000 to 1800 Volts.				6-32 Inch Insulation, for 2000 to 2800 Volts			
B. & S. G.	Area. Circular Mils.	Diam. of Bare Copper. Mils.	Weight 1000 Feet. lbs.	Diam. Mils.	Cents per Foot.	Telegraph Code.	Weight 1000 Feet. lbs.	Diam. Mils.	Cents per Foot.	Telegraph Code.	Weight 1000 Feet. lbs.	Diam. Mils.	Cents per Foot.	Telegraph Code.
14	4107	64.	395	465	8.4	coff.	458	525	9.0	cohesible.	520	590	9.9	collared.
13	5178	72.	416	475	8.7	coffeemill.	480	535	10.05	cohesion.	543	600	11.0	collatable.
12	6530	81.	532	487	9.3	coffeepot.	610	550	11.4	cohesive.	695	612	12.6	collative.
11	8234	91.	558	495	10.5	cofferdam.	637	558	12.0	cohorting.	725	620	13.4	collaud.
10	**10381**	**102.**	**583**	**505**	**11.85**	**cofferer.**	**662**	**568**	**12.9**	**coif.**	**743**	**630**	**14.1**	**colleague.**
9	13094	114.	610	515	12.9	coffers.	690	580	14.0	coifed.	777	645	15.2	collegian.
8	16509	128.	639	531	13.8	coffined.	721	594	15.0	coifing.	809	656	16.2	collegiate.
7	20816	163.	777	600	16.5	coffining.	877	663	17.85	coiffure.	975	725	19.4	collet.
6	26250	188.	922	625	19.2	cofound.	1031	688	20.7	coin.	1144	750	22.5	colletic.
5	**33102**	**219.**	**992**	**656**	**21.0**	**cog.**	**1103**	**719**	**22.5**	**coincide.**	**1218**	**781**	**24.3**	**collie.**
4	41742	250.	1066	688	23.25	cogenial.	1180	750	24.75	coining.	1298	813	26.7	collieries.
3	52634	281.	1146	719	25.7	cogent.	1263	781	27.3	coition.	1384	844	29.0	collision.
2	66333	313.	1238	750	29.0	cogently.	1358	813	30.6	cojuror.	1482	875	32.3	collocate.

1	83694	344.	1340	781	34.0	cogger.	1466	844	36.0	cokers.	1595	906	37.5	collodion.
0	105392	375.	1885	875	42.0	coggle.	2031	938	44.0	coking.	2185	1000	46.2	colloping.
00	133079	422.	2070	922	48.0	cogitable.	2208	984	50.0	colander.	2365	1047	52.2	colloquial.
000	167805	500.	2320	1000	55.5	cogitation.	2456	1063	57.8	colature.	2625	1125	60.0	colloquist.
0000	211600	547.	2563	1047	64.5	cogitative.	2700	1110	66.8	colchicum.	2860	1172	69.0	colloquy.
.....	250000	594.	2768	1090	72.0	cogman.	2918	1150	74.3	coldly.	3084	1215	76.5	collusive.
.....	300000	625.	3001	1125	82.0	cogniac.	3153	1188	84.0	coldness.	3318	1250	86.3	collusory.
.....	350000	656.	3240	1156	91.5	cognition.	3397	1220	94.0	colegatee.	3573	1280	96.6	colonial.
.....	400000	688.	3481	1188	101.0	cognizance.	3643	1250	103.5	colemouse.	3829	1313	106.0	colonist.
.....	450000	735.	3723	1240	111.0	cognizee.	3890	1300	113.0	coleoptera.	4086	1360	115.5	colonize.
.....	500000	781.	3966	1281	121.0	cognizor.	4138	1344	123.0	coleperch.	4343	1406	126.0	colonnade.
.....	550000	828.	4209	1328	130.5	cognomen.	4387	1390	132.8	colessor.	4601	1453	136.0	colonies.
.....	600000	875.	4453	1375	140.0	cognovit.	4637	1438	142.5	colestaff.	4860	1500	146.0	colophene.
.....	650000	925.	4699	1425	150.0	cogue.	4889	1488	153.0	colewort.	5120	1550	156.0	colophony.
.....	700000	969.	4946	1470	160.0	cogwear.	5142	1530	163.5	colicky.	5381	1595	166.5	colorable.
.....	750000	1000.	5193	1500	170.0	cogwheel.	5395	1563	173.3	coliseum.	5642	1625	176.3	colorblind.
.....	800000	1045.	5442	1545	180.0	coheir.	5649	1610	183.0	colitis.	5903	1670	186.0	colorist.
.....	850000	1090.	5692	1590	190.0	coheiress.	5904	1655	192.0	coll.	6165	1715	195.0	colorless.
.....	900000	1125.	5943	1625	200.0	coherald.	6160	1688	202.5	collapsing.	6429	1750	205.5	colorman.
.....	950000	1156.	6196	1656	208.0	cohere.	6416	1718	211.5	collarage.	6692	1780	214.5	colossal.
.....	1000000	1188.	6450	1688	219.0	coherence.	6683	1750	222.0	collarbone.	6956	1815	226.5	colossean.

See Page 23 for list prices of cables with 1-64" to 3-32" insulation. See pages 26, 27 and 83 for illnstrations and important information.
Unless otherwise stated, quotations are for, and orders will be filled with, fiber insulated cable. (Copyright, 1896, by J. W. Marsh.)







SEE OPPOSITE PAGE FOR ILLUSTRATIONS.

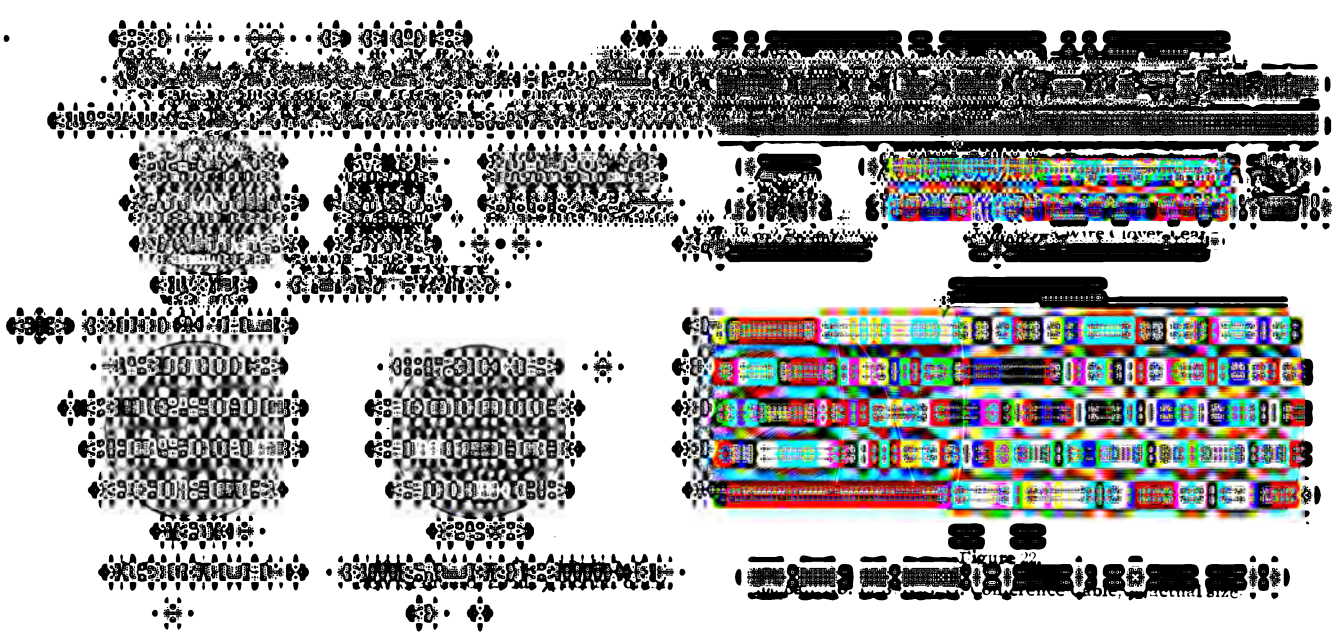
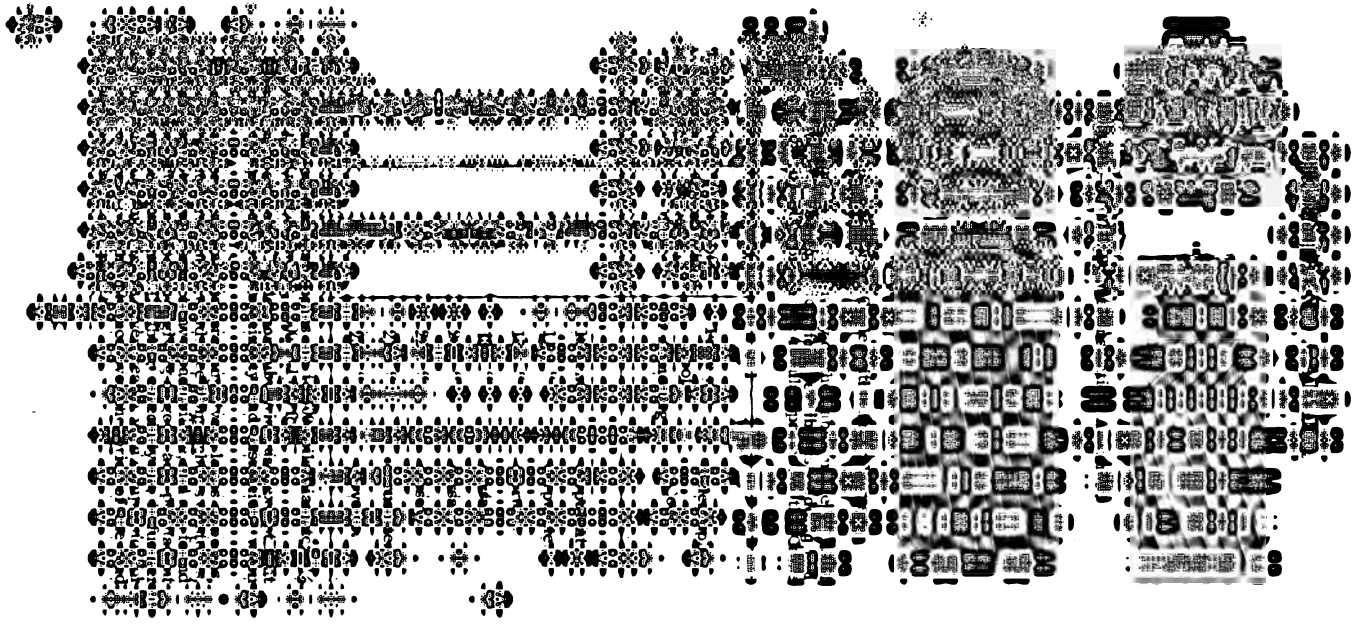
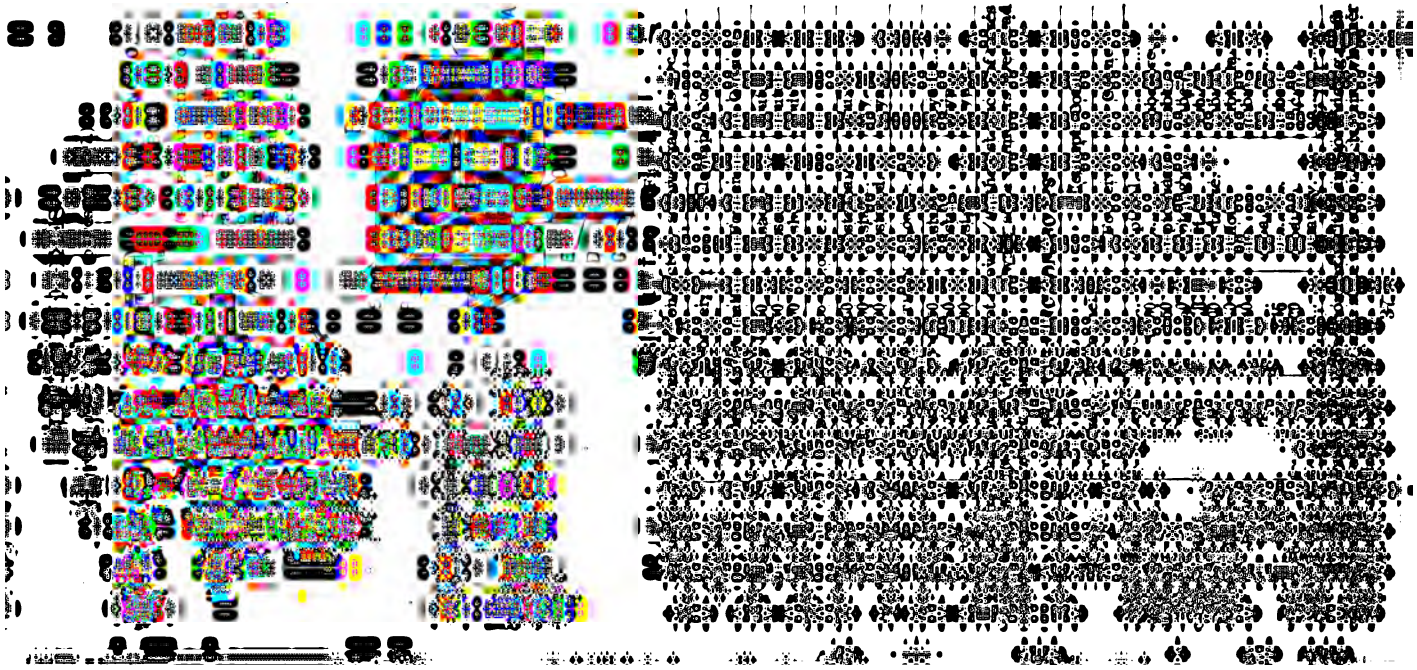


Figure 22.

No. of Conductors and Form of Cable.	STANDARD LEAD, FOR UNDERGROUND USE. Brown & Sharpe Gauge Number. 12	14	16	18	20	22	Telegraph Code.	LIGHT LEAD, FOR AERIAL OR HOUSE USE. Brown & Sharpe Gauge Number. 12	14	16	18	20	22	Telegraph Code.
2, Flat	16c.	12c.	10c.	8 5c.	7.5c.	7c.	comical.	15c.	11c.	9c.	7.5c.	7c.	7c.	conics.
3, "	21	17	14	12.5	11	10	comicry.	19	15	12	11	10	9	conifer.
3, Clover Leaf	21	17	14	12 5	11	10	comity.	19	15	12	11	10	9	conite.
3, Round	21	17	14	12.5	11	10	command.	19	15	12	11	10	9	conjure.
4, Square	**25**	**21**	**17**	**15**	**13**	**12**	**commerce.**	**23**	**18**	**15**	**13**	**12**	**11**	**connate.**
4, Flat	25	21	17	15	13	12	communal.	23	18	15	13	12	11	conoid.
4, Round	25	21	17	.5	13	12	communes.	23	18	15	13	12	11	conquer.
5, Square	29	24	20	17	15	14	companion.	27	23	19	16	14	13	consols.
5, Flat	29	24	20	17	15	14	compart.	27	23	19	16	14	13	consort.
5, Round	**29**	**24**	**20**	**17**	**15**	**14**	**compend.**	**27**	**23**	**19**	**16**	**14**	**13**	**contour.**
6, Flat	33	28	22	19	17	15	complexly.	32	25	21	18	16	14	convent.
6, Round	33	28	22	19	17	15	complaint.	32	25	21	18	16	14	convex.
7, Flat	37	28	24	21	18	16	composer.	34	25	22	19	17	15	convict.
7, Round	37	28	24	21	18	16	comrade.	34	25	22	19	17	15	convoke
8, "	**41**	**30**	**26**	**23**	**19**	**17**	**conatus.**	**38**	**27**	**23**	**20**	**17**	**16**	**cook.**
10, "	53	42	29	25	21	19	conceited.	49	38	25	22	18	17	cookery
15, "	72	55	41	36	27	25	concert.	68	51	37	32	24	22	cooler.
20, "	88	67	53	45	32	29	conch.	81	63	49	41	28	26	copal.
25, "	103	79	64	52	37	33	conchifer.	93	74	59	47	33	30	copeck.
30, "	**118**	**91**	**74**	**57**	**42**	**37**	**conchoid.**	**108**	**85**	**68**	**53**	**38**	**34**	**coping.**
35, "	133	103	84	62	47	41	conclave.	122	96	77	59	43	38	coplant.
50, "	174	138	112	82	60	52	concord.	162	126	102	77	56	49	coppice
75, "	.....	179	150	107	84	71	concourse.	.....	167	140	98	79	67	copse.
100, "	.....	216	180	129	106	99	concubine.	.....	200	168	118	97	82	coptic.
125, "	.....	.....	.....	156	**126**	**106**	**concuss.**	.....	.....	.....	**143**	**114**	**94**	**copula.**
150, "	.....	.....	.....	.....	142	121	condign.	.....	.....	.....	.....	130	110	copyist.
175, "	.....	.....	.....	.....	157	136	condignly.	.....	.....	.....	.....	144	124	coquet.
200, "	.....	.....	.....	.....	171	150	condiment.	.....	.....	.....	.....	157	137	cork.
Telegraph Code to designate gauge	condole	condor	confab	confect	confide	conflux	.....	cornel	cornice.	corona	coronet.	corporal	corpus	.....

See opposite page for illustrations. Quotations and orders are for fiber insulated cables unless otherwise stated. Copyright, 1896, by J. W. Marsh.





MISCELLANEOUS TOOLS AND DEVICES.

For use in placing and connecting underground or overhead cables and wires.

For description of each article see pages referred to below.

Article.	See Page	Price.	Telegraph Code.
Tubular **braid** for covering telephone and telegrapl. wire splices	102	$ 1.50 per lb.	cudgeling.
Cable **grip** for drawing in cables	.....	15.00 each.	cudweed.
Insulating tube or sleeve, paper. (State diameter and kind of cable)	125	.10 "	cufic.
Insulation-cutting tool for removing insulation of conductors	108	5.00 "	cuirassier.
Complete **joint** mould for making joints between cable sections	108	10.00 "	cuisine.
Sleeve **joint** mould for making cast solder wipe at each end of lead sleeve	104	15.00 "	culex.
Lead sleeve or tube for sleeve **joint** on cables. (State diameter and kind of cable)	104	.12½ per lb.	cullender.
Lead tees for branch **joints** or connections. (State sizes and kinds of cable)	104	.20 "	culinary.
Lead-cutting tool for removing lead cover of cables	108	5.00 each.	cullion.
Scoring tool for marking and limiting length of lead to be removed	105	3.00 "	culm.
Rotary wire-**splicing** tool	104	$ 1.50	cuneatic.
Wire-**splicing** tongs for making wire joints	105	20.00	cunning.
Copper blanks for **wire splice** made by last named wire splicing tongs. (State size of conductor)	106	1.15 per lb.	cunningly.
Cable **supports** for manholes	106	.10 each.	cupboard.
Black rubber **tape**, ½ inch wide (ozite)	106	1 15 per lb.	cupid.
Black rubber **tape**, ¾ inch wide (ozite)	106	1.15 "	cupidity.
White rubber **tape**, ½ inch wide	106	1.15 "	cupreous.
White rubber **tape**, ¾ inch wide	106	1.15 "	cuprite.
Cast iron **terminal** cups for round cables	91	.25 each.	curacy.
18 in. paper tubes for wire splices	102	1.00 per 100.	curatrix.
Lightning arresters	92	.30 each.	cur.
" high class	92	On application	curdle.
" electric light	98	" "	curfew.

GENERAL
TELEGRAPH CODE

FOR USE WITH

THE STANDARD UNDERGROUND CABLE CO.

Copyright, 1896, by J. W. MARSH.

The Telegraph Code, Contained in No. 6 Handbook, published in 1888, has been so freely used and so highly commended, that it is considered certain the reproduction of this feature on a much enlarged and improved plan will meet with general favor. A code of this kind reduces the expense of telegraphing orders and inquiries, and lessens liability of mistakes. The following specimen will illustrate the economy of the Code, namely:

"Poacher falmegzy cloudage plunder dingdong danube"
"phantasm daladaltalzad coining dentition,"

Which means:

"Ship as soon as possible five thousand pounds"
"No. 6 Brown & Sharpe's Gauge Standard Weather—"
"proof Line Wire; how soon can you ship? What"
"is the freight rate per hundred pounds"
"to destination? Answer by letter. Telegraph"
"lowest price and earliest delivery of three"
"and three-fourths miles No. 4 Brown & Sharpe's"
"Gauge, single Conductor, Waring Electric Light"
"Cable with five thirty-seconds inch insula-"
"tion, delivered f. o. b. cars here."

Two blank pages are provided for private Code, as the Handbook telegraph code will doubtless be used between individual members, officers and employees of Companies other than our own, and they will, naturally, have special articles and expressions relating only to their business, for which it will be convenient to have a telegraph code; this will be especially the case with Construction Companies and Electrical Supply Companies having salesmen or construction corps at points away from the home office and telephone companies having sub-exchanges outside of the city in which the general office is located.

All Code Words beginning with the letter "c" will be found on pages ten to thirty-six in the several price lists, to designate specific articles, size of conductor, character of insulation, etc. The General Code following does not include any words beginning with the letter "c."

For the convenience of foreign correspondents in sending cablegrams, we have registered the following cable addresses, viz:

General Offices, Pittsburgh, Pa.
Address: "Cables, Pittsburgh."

Branch Office, New York City, N. Y.
Address: "Cablemaker, New York."

Have not been **able** to	dab.
Have you been **able** to?	dabblers.
Will be **able** to	dabbling.
Absent from office	dabsters.
Will **accede** to terms named	dacapos.
Cannot **accede** to terms named	dacers.
Will you **accept**?	dacians.
Will **accept**	dacoits.
Will not **accept**	dactylic.
Wire at once if **accepted** or not	dactyls.
Subject to telegraphic **acceptance** to-day	dados.
Subject to **acceptance** within ——— days	daffodil.
Will greatly **accommodate** us if you will	daftish.
Will do it to **accommodate** (you)	daggers.
In **accordance** with ———	daglocks.
Not in **accordance** with ———	dagons.
According to contract	dahlia.
Not **according** to contract	dainty.
On (for) **account** of ———	dainties.
Statement of **account**	dairyman.
Account averages due	daisies.
To which **add** the cost of ———	damasks.
To which should be **added**	dallops.
In **addition** to	damian.
How did you **address** ———?	dampish.
Was **addressed** to ———	damsel.
Please note an **advance** of ———	damson.
Expect further **advance** (of, on)	dancing.
Would you **advise**	dander.
Would **advise** you to	dandify.
Would not **advise** you to	dandling.
Advise fully about	dandruff.
Unless otherwise **advised**	dandy.
Unless otherwise **advised** will assume that	danesman.
Will you **agree** to ———	daneworts.
Will **agree** to	danishness.
Cannot **agree** to	danker.
The total **amount**	dankist.
Answer by telegraph (day message)	dannocks.
Answer by night message	danskers.
Answer by letter	danube.
Please telegraph **answer** to our communication of ———	daphnes.
Answer (ing) your communication of this date	daphnite.
Answer (ing) your communication of ———	dapperly.
Will give you **answer** by ———	daric.
Must have **answer** by ———	darkish.
Not yet **arrived**	darksome.
Pay particular **attention** to ———	darlings.
Pay no **attention** to ———	darns.
Call your **attention** to ———	daroos.
Matter shall have best **attention**	darter.
Have no **authority** to ———	darting.
Are they (is he) **authorized** to ———	dashers.
Balance on hand is ———	dashpots.
Balance due on order (is) ———	dastards.
Balance will go ———	datelessly.
On the **basis** of ———	datives.
On what **basis** are you going	datums.
Will **be** in ———	dauber.
Will **be** here ———	daubing.
When will you **begin** ———	daughter.
Expect to **begin** about ———	dauntless.
In **behalf** of ———	dauphin.
Bid must be put in on ———	davit.
Bill of lading and invoice	dawdle.
Have you **bought**	dawdling.
Have **bought**	dawish.
Have not **bought**	dawk.
Provide the **cable** with a coating of anti-corrosive compound	dawker.
Provide the **cable** with saturated fibrous covering over lead cover	dawning.
Provide the **cable** with two saturated coverings over lead cover	daydream.
Waring anti-induction **cable**	daystars.

Waring bunched **cables**	daze.
Waring Electric Light **Cable**	dazzler.
Waring Electric Light and Power **Cable**	dazzling.
Two Conductor Electric Light **Cable**	deaconess.
Conner bunched Electric Light **Cable**	de..eyes.
Heavy leaded **cable** for submarine use	deadlock.
Heavy leaded **cable** with exterior saturated fibrous covering for submarine use	deadliness.
Iron armored **cable** for submarine use	deafener.
Aerial **cable**	deafening.
Underground **cable**	dean.
The **cable** to be placed	deaneries.
Cable hanger (See "Hanger,")	deanery.
Office **cable**	debases.
Office **cable** with———conductors	debasings.
Acheson **cable** protector	debaters.
Electro-static **capacity**	debaucher.
Electro static **capacity** of———Microfarads per mile	debonairly.
In **carload** lots	debutant.
Less than **carload** lots	decadent.
Did not exercise **care** (at, in)	decadist.
Utmost **care** must be used	decagons.
Were very **careful** to (about)	decamps.
Such is the **case**	decants.
That is not the **case**	decanter.
In that **case**	decapod.
In all **cases**	decapodal.
Cash on delivery	decastich.
Cash in thirty days	decaying.
Half **cash**, balance in———days	deceased.
Centre of distribution	decedent.
Cents (see "Numeral Code," on pages 47 & 54 b	decimate.
Change order for (of)———	decking.
Too late to **change**	declaiming.
Charges will amount to———	decoct.
Charges will be very heavy	decore.
Circular mils (see "Mils.")	
Under the **circumstances**	decorously
Telegraph **Code** (see "Telegraph.")	
Ship in **coils**	decorum.
What **color** or **colors** do you want?	decoyer.
The only **color** on hand	decoyings.
Can send **colors** named	decrees.
Immaterial what **colors** are sent	decrescent
Red and White	dedicates.
Blue and White	dedimus.
Green and Gold	dedolent.
Red and Gold	deeds.
Canary Yellow	deemster.
Any other **color** will do if **color** named not on hand	deerskins.
When do you expect to **commence**?	defaces.
Expect to **commence**———	defacing.
Will not allow any **commission**	defamers.
———**commission** will be allowed	defaming.
In **competition** with———	defeature.
When will you **complete**———	defecator.
Order will be **completed**———	defender.
Order was **completed**———	defiant.
Upon **completion** of———	defier.
Send C. O. D. by express	defiles.
Your financial standing being unknown we will send goods C. O. D. unless otherwise instructed	defiling.
P. & B. Electrical **Compound**	deflect.
Insulating **Compound** (see "Insulation.")	defluous.
On what **condition** will you———	deflux.
Upon **condition** that———	deforming.
The **conditions** are———	defrauder.
Will not agree to the **conditions**	defrayal.
Conductivity to be guaranteed	deftly.
Ditto, 98 per cent. of that of chemically pure copper	deftness.
———Strands to equal in cross-section, a solid **conductor** of (No.)	defunctly.

The **conductor** to be composed of small strands so as to be flexible	defyers.
Flexible **conductor**	degrades.
The **conductors** to be twisted in pairs	degust.
The **conductors** to be twisted in fours	dehiscent.
Cement lined **conduit**	dehort.
Iron pipe **conduit**	dehusking.
Creosoted wood **conduit**	deicide.
Dorset **conduit**	deifics.
P. & B. **conduit**	deifical.
Distributing **conduit**	deifier.
Conduit consists of———	deign.
What kind of **conduit**	deist.
Are using ——— **conduit**	deistic.
Inside diameter of **conduit**	deitate.
In **consequence** of which	dejection.
In **consequence** of———	dejectly.
In **consideration** of ———	delegate.
Contract closed	delete.
Contract awarded	deletion.
Contract will be awarded	delft.
Unless advised to the **contrary** in meantime	deliacal.
Approximate estimate of **cost** of———	delicate.
Send detailed approximate estimate of **cost** of——	delict.
Will you extend **credit**	delight.
Cannot extend **Credit**; reports unsatisfactory	delirium.
Credit will be granted if reports satisfactory; give references	delphian.
State **Current** used, in Volts and Amperes	deltaic.
Ditto, and whether direct or alternating, also distance from dynamo to centre of distribution	deltoidal.
Current of ——— Volts at ———Amperes	deluges.
Alternating **Current**	delvers.
Direct **Current**	delvings.
Maximum **Current** will be———	demeanor.
What is the nature of the **Damage**	demented.
The **Damage** is ———	demerit.
———has been **Damaged** by ———	demijohn.
On what **date** will you ———	demises.
———Is the earliest **date** at which it can be (done)	demising.
How much can you send per **day**?	demitint.
———Can be sent per **day**	democrat.
In a **day** or two	demolish.
———**days** after date	demons.
In three to five **days**	demoness.
In eight to ten **days**	demoniacs.
In thirty **days**	demonism.
In sixty **days**	demonize.
In ninety **days**	demonship.
Have you **decided** (to)	demotic.
Have not yet **decided**, will do so———	demurely.
Have **decided** (to)———	denarius.
Find must **decline**	dendritic.
Do not **delay**	denim.
If there is no **delay**	denizens.
Will be no **delay**	dental.
Have (has) been unavoidably **delayed**	dentary.
Have been **delayed** by the ———	dentated.
Delivered f. o. b. cars in ———	dentists.
Delivered f. o. b. cars here	dentition.
Delivered f. o. b. cars in Pittsburgh	dentoidal.
Delivered f. o. b. cars at destination	depicter.
Delivered as fast as needed within———	depilous.
To be **delivered** as required between——and——	depletion.
To be **delivered** at———	deplorer.
Delivery to be completed by———	deplume.
Delivery to begin———	depone.
Will you guarantee **delivery** by———	deposal.
Will guarantee **delivery** by the———	depravity.
Cannot guarantee **delivery** before	depredate.
Depending upon———	deputies.
What is the **diameter** of———	derailer.
———(it) is———mils in **diameter**	derailing.
The cable is———mils in **diameter**	deranged.
Conductor is———mils in **diameter**	deride.
For **diameter**, see———	derisive.

The **diameter** is———..... derisory.
What is your best **discount** from list prices for (here state quantity, then article)..... derivate.
Discount from list prices..... dermal.
Ditto, on article and quantity named..... dermatic.
Ditto, on article and quantity named is——— per cent..... dermis.
Ditto, on article and quantity named is———cents per foot..... dernier.
Ditto, on article and quantity named is——— cents per pound..... derogate.
Distribution (see "Center.")..... derricks.
Will do the best we possibly can..... dervishes.
Do the best you possible can..... descended.
Shall we **do** so?..... descry.
Do so (it)..... desecrate.
Can **do** nothing until———..... deserter.
Hope can **do** better..... desertriz.
Send the **documents**..... desks.
Cash against **documents** (see "Terms.")..... desmine.
———**Dollars** each..... despair.
———**Dollars** per———..... despisal.
———**Dollars** per Hundred..... despoil.
———**Dollars** per Yard..... despot.
———**Dollars** per gallon..... despotism.
The best that could (can) be **done**..... despume.
What have you **done** about———..... destitute.
Have **done**..... desultory.
If not already **done**.....
Will deposit sight **draft** on you to day, unless advised to the contrary, for———dollars..... detective.
Please protect our **draft** for———..... deterges.
Draft has not been protected..... detest.
Will draw on you at sight to-morrow unless advised to contrary for———Dollars..... detonizer.
May we **draw** for amount of———..... detortion.
You may **draw** for———..... detractor.
Do not **draw** on us..... detrital.
Defer **drawing** until———..... deuce.
Account long past **due**..... devastate.
Account will be **due**———..... devex.
Balance **due** is———..... devious.
Duplicate our order of (number)———..... devonian.
Send immediately **duplicate** of———..... devotees.
Send **duplicate** copy of invoice, dated———..... devout.
The price does not include **duty**..... devoutful.
Price, "**duty** paid"..... dewdrop.
One of **each** of the following..... dewfall.
———Of **each** of the following..... dewiness.
Early as possible..... dextral.
Earlier, if possible..... dextrous.
The **effect** will be———..... diabetes.
What will be the **effect**?..... diabolism.
Make every possible **effort** to———..... diaconal.
Personal **endorsement**..... diacope.
Estimate (see "Cost.")..... diacritic.
Make thorough **examination** of———..... diagnose.
Have **examined** very carefully and find———..... dialectal.
Not to **exceed**———..... dialing.
With the **exception** of———..... dialogue.
Will make **exception** in this case..... dialysis.
Expenses to be paid by———..... diandrous.
Explain fully by letter..... diapase.
See **explanation** in———..... diaper.
Send by **express**..... diarist.
Send by **express**, C. O. D..... diastase.
Express rate per one hundred pounds to———..... diastole.
Express rate per one hundred pounds to destination..... diatom.
Express charges to be paid by you..... diatomic.
Will not pay **express** charges..... diatribes.
We will pay **express** charges..... dibstone.
The exact **facts** in the case..... dicast.
Do not **fail** to———..... dice.
Will not **fail** to———..... dickens.
Have failed (to)———.....

Have they ever **failed**, and if so, give particulars..	dicrotic.
They have never **failed**.....	dictate.
They **failed** in———for———.....	dictions.
In good **faith**	dictum.
As **far** as possible	didal.
As **far** as we know	diestock.
As **fast** as possible.....	dieter.
In **favor** of———.....	diffident.
As a special **favor**	diffracted.
Need not **fear**	diffuser.
———**Feet** in length.....	digested.
———**Feet** wide.....	digestive.
———**Feet** deep.....	digital
———**Feet** in diameter.....	dignity.
———**Feet** in circumference.....	digressed.
———**Feet** per pound.....	dihedral.
See **figure**———of Handbook No. XV.....	diking.
As illustrated in **figure**———of Handbook No. XV	dilated.
See **figure**———of———.....	dilating.
A very close **figure**.....	diloge.
Have **figured** as close as possible.....	diluter.
Figure(d) approximately (if) cannot give exact figures	diluvial.
There is no such **firm** (party) known here.....	dimes.
Flexible. (See **conductor**).....	
The **freight** must be prepaid.....	dimly.
Freight rate per one hundred pounds to——— ...	dimness.
Freight rate per one hundred pounds to destination.....	dimpless.
What is the **freight** rate per one hundred pounds to destination.....	dingdong.
Send by **freight**.....	dinginess.
Freight allowed to———.....	diocesan.
Freight allowed to destination.....	diopter.
Can you **furnish**———.....	diorama.
Can **furnish**———...	dioritic.
Cannot **furnish**———.....	dioxide.
Brown & Sharpe, or American, Wire **Gauge**	diplomas.
Birmingham Wire **Gauge**.....	dippers.
Edison Wire **Gauge**.....	dipteral.
New British or Standard Wire **Gauge**.....	direfully.
What Wire **Gauge**?.....	direness.
Name of Wire **Gauge** not stated in order.....	dirigent.
Number (size) of Wire **Gauge** not stated in order..	dirks.
What size (number) Wire **Gauge** shall we send?...	disally.
———are undoubtedly **good**.....	disarm.
Perfectly **good** for amount named.....	disaster.
Consider them **good** for a credit of———dollars for———.....	disavow.
———are not financially **good**.....	disband.
Guarantee the account.....	discal.
A substantial **guarantee**.....	disciple.
Give no **guarantee**.....	discord.
All on **hand**.....	discourse.
Have none on **hand**.....	disdain.
Entire amount on **hand**.....	disease.
Handbook No. XI.....	niter.
Refer you to Handbook No. XV page———.....	nitrate.
Do not use telegraph code of **Handbook** No. XI it is superseded by this **Handbook** No. XV.....	nitric.
Malleable Iron Cable **Hangers**.....	nitrify.
Must **have** it (them).....	nitrogen.
May probably go a little **higher**.....	nivose.
Will undoubtedly go **higher**	nobbler.
Hold subject to your order.....	nobility.
Hold subject to our order.....	nobless.
Hold until further orders.....	nobly.
Cannot **hold** longer than———.....	nocent.
———Is absent just now; will be **home**———..	noctule.
———Will be at **home** by———.....	nocturnal.
Are in a great **hurry** for (this).....	nodated.
Hurry order number ———.....	nodding.
Will **hurry** it all we can.....	node.
Identifying mark (counter) on cable.....	nodical.
Idle, waiting for arrival of———..... ..	noise.
If so..... ..	noiseful.

nd us **immediately**———	noiseless.
his is very **important**	nomadic.
t is very **important** that———	nominate.
Is it important?	nominor.
Find it impossible to———	nonjuror.
Consider it impracticable to ———	nonpareil.
Will see a marked improvement	noontide.
———**Inch (inches)** long	nopal.
———**Inch (inches)** wide	norsemen.
———**Inch (inches)** deep	norwegian.
———**Inch (inches)** thick	nosing.
———**Inch (inches)** in diameter	nostrum.
———**Inch (inches)** in circumference	notches.
Does not include	notional.
Must be included	noun.
Inclusive of everything	novel.
Will indemnify you	novelist.
Will indemnify———	novice.
Name of informant	noxious.
Send definite information	nozzle.
Information reliable	nubia.
Information unreliable	nudging.
Information full and satisfactory	nudity.
Wish to be informed as to (whether)	nugatory.
Have been informed	numbness.
Will keep you fully informed (as to)	numbskull.
Insist upon	nunciate.
Will not insist upon	nunnish.
———Has been **insolvent** for some time	nuptials.
———Has never been **insolvent**	nurse.
Wait instructions (as to)	nursing.
Have given instructions (to)	nursemaid.
Have given no instructions	nutbone.
Followed the instructions given (by)	nutgall.
Insulated wire (see "Wire.")	nuthook.
Insulated by ——— braids	nutting.
Insulated by ——— wraps	nymphal.
Insulated by one wrap of cotton	oafish.
Insulated by two wraps of cotton	oak.
Insulated by one wrap of silk	oakum.
Insulated by two wraps of silk	oared.
Diameter of **insulated** wire including the wire and **insulating** covering	oarweed.
Waring insulating compound	oat.
Insulating compound for filling cable joints (or splice boxes)	oatcake.
Insulating compound for filling cable terminals	oatmalt.
Thickness of insulation all around the conductor	obeisance.
What is the insulation resistance per mile of———	obesity.
Insulation per mile is———megohms	obituary.
Insulation resistance per mile is———ohms	oblate.
Standard insulation	oblivion.
Extra heavy insulation	oboe.
Specially light insulation	obolize.
Insulation 3-32 inch thick	obscenity.
Insulation 4-32 inch thick	obsequy.
Insulation 5-32 inch thick	obtuse.
Insulation 6-32 inch thick	obtusion.
Insulation 7-32 inch thick	obverse.
Insulation 8-32 inch thick	occiput.
What thickness of insulation	occulted.
Insulation resistance	oceanic.
Interest at the rate of six per cent per annum	ocellus.
Interest at the rate of ——— per cent. per annum	octagon.
Have no invoice of———	octander.
Send invoice of———	octaroon.
Invoice was mailed	octavos.
———affairs are very much **involved**	oculate.
Are not involved in	oddity.
First item (paragraph) **in**———	odeon.
Last item (paragraph) **in**———	odin.
———**item** (paragraph) in our communication (of)———	offspring.
———**item** (paragraph) in your communication (of)———	ogle.
———**will make joints** on cable	ogress.

Not including making **joints**	ointment.
Cable **joints.** (See also "Splice Box")	oleander.
Cable **joints** to be made by———	oleate.
Send expert hand to make **joints**	olefiant.
Joints will be finished———	olympia.
Do you **know**?	omega.
Do not **know**	omen.
Have no **knowledge** of———	ominous.
Cable has been **laid**	omnific.
Cable to be **laid** (placed) in (on)———	onset.
Cable to be **laid** and jointed by———	onyx.
Has been **laid** over until———	opacity.
Cable will be **laid**	opacular.
Cable yet to be **laid**	opaline.
Too **large**	operatic.
Not **large** enough	operose.
The **largest** you possibly can	opine.
Too **late**	opining.
Not **later** than———	optate.
———is the **latest** possible time (for)———	optical.
Will **lay** the cable and make the joints	optician.
Ditto, but not including boxing, trenching and refilling	optimism.
Will begin **laying** the cable	opus.
Will finish **laying** the cable	oracle.
The **laying** of the cable	orally.
The **lead** cover to be (weigh)———	oration.
The **lead** cover is———	oratory.
What is the thickness of **lead** cover?	orbital.
Standard **lead**	orchanet.
Extra heavy **lead**	orchid.
Light **lead**	ordain.
Leave it entirely to———	ordeal.
Expect-s to **leave**———	orgy.
What is the **length** of———	oriel.
In one continuous **length**	oriental.
To be in **lengths** as follows:	orifice.
Give **lengths** in detail as required	orisons.
Wait exact detail **lengths** before proceeding with order	orlop.
Send regular commercial **lengths**	ormolu.
Less than———	orpheus.
Not **less** than———	orthodox.
Cannot take **less** (than)———	osculate.
See **letter** of———	osier.
Received your **letter** (of)———	ostracism.
Have not received your **letter** (of)———	ostragoth.
Please answer our **letter** of———	otalgy.
As per your **letter** of———	outcast.
As per our **letter** of———	outgrown.
Liabilities and assests	outran.
Offer is very **liberal**	ovate.
File **lien** on———	ovid.
Would **like** to have———	owlish.
How **long**?	oxalic.
As **long** as possible	oxygen.
How **long** before you can———	oyster.
Will **lose** nothing by it	pabulum.
At a **loss**	padding.
At a **loss** of——— per cent	paddler.
At what per cent. of **loss** do you expect to run	paddy.
Expect to run at a **loss** of———per cent	padlock.
———are **lower** than———	pagan
———(it) cannot be **made**	pageant.
———(it) is **made**	pagoda.
Send by **mail**	painless.
Send by special delivery **mail**	palace.
Mail (it) early to-day	paladin.
———Cannot **make** it (them) before———	palatial.
In such a **manner** as to———	paleness.
What is the **matter** with———	palestra.
Nothing the **matter** with———	paletot.
Something the **matter** with———	palfry.
In the **matter** of———	palisade.
Let the **matter** rest	pallid.
In the **middle** of———	palm.

Circular **mils** in cross section	palmate.
———**Mils** in diameter	palmer.
Have been **misinformed**	palmetto.
Have not been **misinformed**	palster.
There is a **mistake** in———	palsey.
There is no **mistake** (in)———	pampas.
During this **month**	panacea.
During (in) **next month**	pancake.
During (in) **the month** of ———	pancreas.
Three **months**	pandect.
Four **months**	pandora.
More than———	paneling.
Not **more** than———	pannier.
How **much** (many)———	panoply.
How **much** (many) do you want	panther.
In as **much** as	panting.
As **much** as possible	pants.
What is the **nature** of the———	papacy.
Of a **nature** to———	papal.
As **near** as you (we) can	papyrus.
As **near** as possible	parable.
Not **near** enough	parabola.
Is it **necessary** to———	parade.
It is **necessary** to———	paradise.
It is not **necessary** to ———	paradox
If absolutely **necessary**	paramount.
If not absolutely **necessary**	parapet.
Will **need**	parasite.
Need it at once	parasol.
Will not **need**	parboil.
Negotiating for———	parental.
Negotiating for purchase of———	parian
Negotiations have been———	parietal.
Net price	parish.
This is the **net** price	parlance.
Take **notice** of———	parlor.
What are the **numbers** of———	parody.
The **numbers** of (on)———	parotid.

NUMERAL TELEGRAPH CODE.

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And	a.	Fourths (4ths)	tal.
1	bal.	Eighths (8ths)	teg.
2	beg.	Sixteenths (16ths)	val.
3	dal.	Thirty-seconds (32nds)	wal.
4	deg.	Sixty-fourths (64ths)	weg.
5	fal.	B. & S. G.	wim.
6	feg.	Cents	yal.
7	gal.	Circular mils	yeg.
8	hal.	Dollars	yid.
9	heg.	Feet	yon.
0	kal.	Miles	zad.
00	mal.	Pence (Sterling)	zeg.
000	meg.	Per centum	zim.
0000	seg.	Pounds (Sterling)	zot.
Decimal (.)	si.	Pounds (Weight)	zy.
		Shillings (Sterling)	z.

Combine these syllables to form any desired number, or quantity and designation. Thus

Examples	falfegsegyeg	means 560,000 Cir. Mils.
	fegsegyon	" 60,000 feet.
	galsifal	" 7.5.
	degfalgalseg	" 4,570,000.
	balahegwal	" 1 and 9-32nds.
	balhegwal	" 19-32nds.
	halzfegzeg	" 8 Shillings, 6 Pence.

NAMES.

———Cable Company	parquet.
———Construction Company	parrot.
———Electric Company	parsee.
———Electric Light Company	parson.
———Electric Light and Power Company	parterre.
———Electric Railway Company	partisan.
———Electrical Supply Company	partridge.
———Electrical Works	parvenu.

NAMES. OBJ—PAT.	pas—pen.
———Express Company	paschal.
———Fire Department	pasha.
———National Bank	pashalic.
———Police Department	pasque.
———Railroad Company	passado.
———Telegraph Company	passkey.
———Telephone Company.	passover.
Brush Electric Light Company	passport.
North American Construction Company	pastel.
Standard Underground Cable Company	pasting.
Ditto, "The Rockery," Chicago, Ill	pastiness.
Ditto, Times Building, New York City, N. Y.	pastoral.
Ditto, Westinghouse Building, Pittsburgh, Pa	pastorship.
Thomson-Houston Electric Light Company	pasture.
United States Electric Light Company	pasty.
United States Illuminating Company	pat.
Westinghouse Electric and Manufacturing Co	patacoon.
Westinghouse Electric Railway Department	patapsco.
Will not object	paternal.
Will you (they) **object**	pathetic.
Will object	pathic.
Do not object	pathless.
Is there any objection	pathos.
Objection can be made	patriarch.
Try to obtain	patriot.
Have occasion for (to)	paucity.
Have no occasion to (for)	pauline.
Send at once	paunch.
Do so at once	pauper.
The only thing to be done (is)———	pavilion.
Open to an offer	pawnee.
Open to negotiation	peaches.
Will be in operation	peacock.
Has been in operation since———	peafowl.
A good opportunity	peanut.
Lose no opportunity (to)———	pearl.
Very much opposed (to)———	pearling.
In order to———	peasant.
In what order?	pectinal.
In the following **order**	pectoral.
In the order named by you	pedal.
In the order named by us	pedantry.
Order number (dated)———	pedestal.
Same as **order** numbered (dated)———	pedigree.
Enter **order** for———	pedler.
Would like to have **order** (for)———	peerage.
Order calls for———	peevish.
Order does not call for———	pegasus.
We have no unfilled order from you (for)———	pelagian.
Do not care to accept order	pelican.
Will not take order at any lower price	pelicoid.
Order will be completed	pelisse.
Will proceed on **order** (of, for)———	pellucid.
Cannot fi.l the **order**	penance.
If you cannot fill the **ordor** (by)———	pencil.
If you cannot fill the order within the time named, wire at once	pendant.
Cannot fill order within time named	pendicle.
Ordered elsewhere on account of———	pendulum.
If ordered to-day	penelope.
If ordered in lots of not less than———	penguin.
Ounces per foot	penitent.
Ounces per———	penman.
What **page** of the book is it on?	pennate.
Refer to **page**———	pennon.
See **page**———of Handbook No. XV	pension.
Will be **paid**	pensive.
Has been **paid**	pentacle.
Twisted **pairs** (see "Conductors")	
On the **part** of———	pentagon.
Telegraph full **particulars**	pentateuch.
Write full **particulars**	pentecost.
Party of the first part	penult.
Party of the second part	penumbra.
Letters **patent**	penury.

Patent applied for	peon.
Infringement of **patent**	peonage.
Character of **pavement**	peonism.
Brick **pavement**	pepper.
Cobblestone **pavement**	pepsin.
Granite block **pavement**	peptics.
Asphaltum **pavement**	percher.
Pavement consists of———	perdition.
Paving to be done by———	perfidy.
Will not **pay**	perfume.
Per cent. (see also Numeral Code, syllable "zim")	peri.
State **plainly** what is required	perigree.
Water-tight **pole** box	perigone.
Water-tight **pole** box of suitable size to contain ———wire cable terminal	periwig.
As a matter of **policy**	perkins.
Quite **positive** about (the matter)	pernis.
If at all **possible**	perseus.
It is not **possible**	persian.
Cannot **possibly** do so	persic.
Matter **postponed** until———	perspire.
Pounds per———	pertness.
Pounds per foot	perturb.
Pounds per thousand feet	peruke.
Pounds per mile	peruvian.
Power of attorney	pesthouse.
Do not consider it **practicable** (to)———	pestilent.
Consider it **practicable** (to)———	pestle.
Take every possible **precaution**	pestling.
If you, (he, they) **prefer**	petaline.
Would much **prefer**	petaloid.
Preferably the latter	petard.
Preferably the former	petrel.
Freight **prepaid**	petrify.
All charges **prepaid**	petronel.
Prepare necessary papers	pettish.
Up to the **present** time	petulant.
Is **president** of the———	pewter.
The **price** depends upon	pfennig.
Telegraph lowest **price** on———	phalanx.
Write lowest **price** on———	phallic.
Telegraph lowest **price** and earliest delivery of ———	phantasm.
Write lowest **price** and earliest delivery of———	phantom.
At lower **price**	pharaoh.
Price is too high (by)———	pharisee.
Cannot name **price** on———do not make it	pharmacy.
Cannot name **price** (before)	pharos.
At the market **price**	pharynx.
Price named is only for immediate acceptance	phasis.
Price named is open for———days only	phengite.
Price at which will furnish (it, or is)———	phenix.
Price named is very low	phial.
At the same **price** (as)	philomot.
The **price** should be higher (than)	philter.
Price list No.———	phiz.
Price list in Handbook No. XV	phlegm.
Price list in Handbook No. XI(superseded, however, by Handbook No. XV)	phlox.
List prices	phoebus.
List prices in Handbook No. XV less discount of ———per cent	phonetic.
List prices in Handbook No. XV less a discount of ———cents per pound	phonics.
All prices and discounts are hereby withdrawn	phosphor
We hereby make an advance of———in **price** of———	phrygian.
Prices named include———	physic.
Prices named are based on———	pianist.
Prices named do not include———	piano.
Prices likely to be higher	piazza.
Prices likely to be lower	pibroch.
The **privilege** of———	picador.
Any **probability** of———	piccolo.
Progress is being made (with)———	pickerel.
Are **prohibited** from———	picket.

Act **promptly**	pickie.
What **proportion**?	pickwick.
A large **proportion**	picnic.
A small **proportion**	picrolite.
In **proportion** to———	picture.
The **prospects** are———	piebald.
What is the **prospect** for (of)———	pieman.
For the **purpose** of———	pierian.
Best **quality**	pietist.
Same **quality** as before	pigeon.
(for) Large-r **quantity**	pigment.
(for) Small-er **quantity**	pigmy.
(for) **Quantity** named	pigweed.
What **quantity**?	pilaster.
Have **quoted**	pilchard.
Unless otherwise advised will **quote**———	piletus.
Would **rather** not———	pilgrim.
Would **rather**———	pillage.
Should **reach** destination by freight on (in)———	pillion.
Should **reach** destination by express on (in)———	pillory.
Read the following as———	pillow.
Read the following as an affirmative	pillwort.
Read the following as a negative	pilose.
Read the following as a question	pilosity.
Have you **received**———	pilot.
We have **received** (it, them)———	pilotage.
We have not **received** (it, them)———	pilser.
Find no **record** of———	pimento.
Find any **record** of———	pimple.
Empty **reels**	pinafore.
Ship as "empty **reels**, returned, having passed over the road filled"	pincase.
Reels of cable	pindar.
Reels of wire	pineal.
Ship it on **reels**	pinery.
To whom can you **refer**?	pining.
Refer you to———	pinnace.
References not satisfactory	pinnated.
Please **remit** at once	pintado.
Will **remit**	pintail.
Remittance was sent on———	pioneer.
Have you **remitted**?	pious.
If you have not **remitted**	pippin.
Repeat———word of your message	pistol.
Have the message **repeated**	piquant.
Waiting for **reply**	piracy.
No **reply** from (to)———	pirates.
The **report** (is) correct	pirogue.
The **report** (is) incorrect	piteous.
Mail us **report** as to———	pitfall.
Send us telegraphic **report** as to———	pitman.
(It) is **reported**———	pittance.
Commercial **reports** (rating) unsatisfactory	pivot.
Commercial **reports** (rating) unsatisfactory; **send** new names	placard.
Commercial **reports** (rating) satisfactory	placid.
Parties financially **responsible**	plagiary.
Parties are not financially **responsible**	plague.
Consider them (it, him) **safe**	plaid.
Same as———	plaiding.
Same as before	plaited.
Send **sample** of (it)———	planary.
Have not received **sample**; send another quickly	planchet.
Quite **satisfactory**	planet.
Will it (that) be **satisfactory**	planish.
Will not be **satisfactory**	plantain.
Are fully **satisfied**	planter.
Feel perfectly **secure** (about)———	plateau.
Security can be given	platen.
Must have good **security**	platinic.
Must have better **security**	platonist.
Send us immediately	platoon.
Send by express to-day	plaudit.
Send by freight to-day	playful.
Send by express C. O. D	plebeian.
Send by first mail	plenitude

Send by mail, special delivery	pleura.
Send balance by———	pleurisy.
Why do you not **send**———	plinth.
Will **send** balance by (on)———	pliocene.
Cannot **send** (it, him)———	plod.
Send as soon as possible	plodder.
Have you **sent**———	plodding.
Have not **sent**———	plover.
When did you **ship?**	plumage.
When will you **ship?**	plumbago.
How soon could (can) you **ship?**	plunder.
Ditto, if ordered to-day?	plunket.
If you can **ship** to-day, enter order for———	plush.
If you can **ship**———on or before———, enter order for (it)	pluto.
Ship to-day, if possible	pluvial.
Ship as soon as possible	poacher.
Ship not later than———	podesta.
Ship by express	podgy.
Ship by fast freight	poem.
Ditto, via———railroad	poematic.
Ship by steamer	poesy.
Ship to our own order (at———)	poetess.
Ship to the order of———	poetic.
Ship as much as possible immediately, and the balance quickly	poetry.
Ship all you possibly can before———	poison.
Ship all you possibly can before———up to———	poker.
Shall we **ship** by express or freight?	polacca.
By what route shall we **ship?**	polander.
By what route did you **ship?**	polar.
Can **ship**	polecat.
Can **ship** at once	polemic.
Can **ship**———days after receipt of order	polenta.
Can **ship**———feet	polish.
Can **ship**———feet per day (there)after———	polka.
Can **ship** as fast as required, if ordered	pollard.
Can (will) **ship** as fast as it can be laid (or strung) and jointed	pollock.
If ordered to-day can **ship**———	pollen.
Cannot possibly **ship** before———	polltax.
Will **ship** (it)———	pollute.
Will **ship** as directed	poltroon.
Shipment to begin	polyglot.
Begin **shipment**———days after receipt of order	pomade.
Shipment will be completed on or before———	pomatum.
Suspend **shipment** of———	pomfret.
All **shipments** to go via———	pommel
All **shipments** will be made by fast freight, unless otherwise specified	pomona.
Have you **shipped** (it)———	pomonic.
Have not **shipped** (it)———	pomp.
(It) was **shipped** on———	pompon.
Must be **shipped** by———	poncho.
———was **shipped** on———and should arrive———	pongee.
When could you begin **shipping**, and how fast could you ship	poniard.
Await **shipping** directions	pontiff
The **shortest** time	pontoon.
At **sight**	pony.
At———days **sight**	poodle.
Sight draft with bill of lading attached	popcorn.
Sight draft with bill of lading and invoice attached	popgun.
So as to———	popinjay.
How **soon** can (will) you———	poplar.
As **soon as** possible	poppy.
A copy of the **specifiations**	populate.
The **specifications** call for———	porch.
According to **specifications**	porcine.
Change in **specifications**	porism.
Splice box	poristic.
Send itemized **statement**	porite.
Store at expense of———	pork.
Find place to **store**	porker.
Strand, (See "Conductor")	
———(this) to be **substituted** in place of———	porkling.

Have been **sued**. ..... porpoise.
A very **superior** article..... porridge.
Far **superior** to———..... portal.
Can you **supply**———..... porthole.
Can **supply**..... portico.
Are you **sure**?..... portly.
If you are **sure**..... portrait.
If you are not **sure**..... posing.
Am not **sure**..... postern.
Are (am) (is) quite **sure**..... postulate.
Be very **sure** ..... portable.
See **table** of———..... potash.
See **table** on page———of Handbook No. XV..... potation.
Have **telegram** from———..... potato.
Your **telegram** just received..... poteen.
Your **telegram** came too late for attention yesterday potency.
Have not received **telegram** (from)———..... potpie.
See **telegram** of———..... pottage.
———word of **telegram** is ———..... pottery.
———word of **telegram** is not understood; please repeat or explain..... pouch.
Telegraph code..... pouched.
Telegraph code of Handbook No.XIis superseded by this code..... pouching.
Telegraph code of Handbook No. XV has been superseded by———..... poulter.
Will **telegraph** you..... poultice.
Please **telegraph** at once (to)..... poultry.
Terminal boxes for connecting cable and air line wires..... pounce.
Acheson Electric Light Cable **terminal**..... pouncing.
Telephone or telegraph cable **terminal**..... poundage.
Telephone or telegraph cable **terminal**, Degenhardt pouter.
Telephone or telegraph cable **terminal**, cast iron with binding posts set in rubber bushings... poutiness.
What are the best **terms**..... pouting.
For **terms** see ———..... poutingly.
Terms are C. O. D. less one per cent. where buyers are not known to us..... poverty.
Terms are cash against bill of lading with receipted invoice attached..... powder.
The **terms** are not satisfactory ..... prairie.
The **terms** are satisfactory..... prance.
Terms———cash, balance in———days..... pranker.
———**test** shows———..... prankish.
Test-ed carefully before shipment..... prate.
Test-ed the cable..... prattle.
Test-ed for static capacity..... prayer.
Test-ed for conductivity ..... prayerful.
Test-ed for insulation..... praying.
Test-ed for continuity..... preach.
Test-ed satisfactory in every respect... ..... preacher.
———(it) is———mils **thick**..... preaching.
———(it) is———inches **thick**... ..... prebend.
What is the **thickness** of———..... precept.
Do you **think**..... prefect.
Do not **think**..... pregnant.
How much **time** can you give?..... prelacy.
How much **time** do you want?..... prelate.
The **time** is too short..... prelude.
Can extend **time** to———..... premier.
Longest possible **time**..... prester.
Shortest possible **time**..... presto.
At the same **time**..... prevision.
Put **tracer** on shipment (of)———..... prideful.
Put telegraphic **tracer** on shipment of———..... priest.
Tracer has been started..... ..... priggery.
No use putting **tracer** on shipment, as it is only due to arrive———..... primacy.
How long will it be in **transit**?..... primal.
Trench to be open-ed by———..... primate.
Trench to be refilled and paved by———..... primer.
Trench open and waiting for (it)———..... primeval.
The result of the **trial**..... priming.
The **trouble** is———..... primrose
The **trouble** is due to———..... prince

What is the cause of the **trouble**?	princely.
Quite **unable** to———	princess.
It is **uncertain**	prioress.
Do not **understand**	prism.
Understand quite clearly	prison.
Do you **understand**?	pristine.
Are we to **understand** that (you)———	privateer.
It would be very **unsafe** to———	privet.
Do nothing **until**———	probate.
Can you **use** (it)———	probity.
Can **use** (it)———	proctor.
Cannot **use** (it)———	prodigal.
It is **useless** to———	prodigy.
Do not **vary**	profane.
Cannot **wait** any longer	profile.
Are **waiting** for———	prolix.
Do you **want**———	pronoun.
Do they **want**———	prophecy.
Very much in **want** of———	prophet.
If you (they) **want**———	prosaic.
If you (they) do not **want**———	prosal.
Do not **want** (to)———	prose.
In what **way**?	prosody.
No other **way**	protean.
In such a **way** as to———	protocol.
The best **way** is (to)———	proudish.
Early this **week**	proverb.
Early next **week**	provost.
Latter part of this **week**	prowess.
Latter part of next **week**	prowler.
A **week** from———	prudery.
In a **week** or ten days	prudish.
In two **weeks**	prunella.
In three **weeks**	prussic.
In four **weeks**	prying.
The first **week** in———	psalm.
The second **week** in———	psalmist.
The third **week** in———	psalter.
The fourth **week** in———	publican.
What is the approximate **weight** of———?	publicist.
What is the approximate **weight** per foot (of)——?	puck.
The approximate **weight** is———	pucker.
Where can we———?	pudding.
Winch for drawing in cable	puffball.
Annunciator **wire** (see "Colors.")	puffin.
Bare copper **wire** (hard drawn)	pugilist.
Bare copper **wire** (soft)	puissant.
Hard drawn copper **wire**	puling.
Duplex **wire** (Twisted pair)	pullet.
Duplex **wire**, laid parallel and braided flat	pulmonic.
Flexible insulated copper electric light **wire**	pulpit.
German silver resistance **wire**	pulsate.
Incandescent lamp cord, silk braided (see "Colors.")	pulse.
Incandescent lamp cord, cotton braided (see "Colors.")	pulsific.
Incandescent lamp cord (see "Colors.")	pumice.
Insulated **wire**	pumper.
Cotton covered magnet **wire**, single wound	puncheon.
Cotton covered magnet **wire**, double wound	pundit.
Silk covered magnet **wire**, single wound	pungent.
Silk covered magnet **wire** double wound	punic.
Office **wire** (see "Colors.")	punish.
Rubber-covered **wire**	punitive.
Telegraph and telephone line **wire**	punster.
Underwriter's **wire**	pupil.
W. A. C. Fire and moisture-proof house **wire**	puppet
"Tip-Top" Fire and water-proof house **wire**	purgation.
"Tip-Top" weatherproof line **wire**	purge.
"Sterling" (double covered) weatherproof line **wire**	purging.
Galvanized iron weatherproof telegraph and telephone **wire**	purifier.
"Standard" weatherproof line **wire**	purify.
Wire, with drab exterior finish	purim.
Wire, with white exterior finish	puritan
For inside **wiring**	purloin.
Ditto, embedded in plaster	purple.

Ditto, placed in molding	purplish.
For overhead wiring	purvey.
With or without	pussy.
Write fully	putanism.
Write fully to———	putative.
Will write fully to-day	putrefy.

THE AMERICAN MORSE CODE.

It consists of dots and dashes recorded on paper strips, or read by the deflections of a magnetic needle to the right and left, or by sounds of varying lengths.

The most common transmitting apparatus consists of a telegraphic key by means of which the main line circuit is readily closed or opened in accordance with the dots and dashes of the alphabet, each station being provided with a key, relay, sounder or register, and a local battery. The code is as follows:

A	. —	N	— .
B	— . . .	O	. .
C	. . .	P	. . . . .
D	— . .	Q	. . — .
E	.	R	. . .
F	. — .	S	. . .
G	— — .	T	—
H	. . . .	U	. . —
I	. .	V	. . . —
J	. — . —	W	. — —
K	— . —	X	— . . —
L	— —	Y	— . — —
M	— —	Z	— — . .

& . — . . .

NUMERALS.

1	. — — —	6	— . . . .
2	. . — —	7	— — — . .
3	. . . — .	8	— — — — .
4	. . . . —	9	— — — — —
5	— — — —	0	— —

PUNCTUATION MARKS.

Period	. . — — — . .	Interrogation	. . — — .
Comma	. — — —	Exclamation	— — — —

Wurtz Double-Pole Non-arcing metal Lightning **arrester**, Type A, for Station use, Alternating Current	rabbeter.
Wurtz Double-pole non-arcing metal Lightning **arrester**, Type A, for line use, Alternating Current	rabbinic.
Wurtz Non-arcing Railway Lightning **arrester**, Type K, for Station use	rabble.
Wurtz Non-arcing Lightning **arrester**, Type K, for car and line use	rabies.
Wurtz Non-arcing Lightning **arrester**, Type I., for direct current station use, (Arc-Lighting)	raccoon.
Lightning **arresters** (fig. 49b) loose	race.
Lightning **arresters** (fig. 49b) mounted on base	racecut.
Lightning **arresters** (fig. 49b) mounted with ground plate	rachitic.
Lightning **arresters**, High Class (fig. 49c)	raciness.
Glass tubes with fuses (fig. 49c) for Lightning **arresters**	racker.
Carbon cylinders for Lightning **arresters**	racketing.
Conference Standard Aerial **cable**	rackrent.
Conference Standard Underground **cable**	radial.
Dry Core **cable**	radiance.
New Standard Underground **cable**	radiate.
New Standard Aerial **cable**, plain lead	radishes.
New Standard Aerial **cable**, saturated braid over lead	raffish.
Special New Standard Aerial **cable**, saturated braid over lead	rafter.
Special New Standard Aerial **cable**, plain lead	raftsman.
Special Standard Underground **cable**	ragfair.
Saturated Core **cable**	ragged.
If omit Saturated covering over lead cover of **cable**, reduce the price	raglan.
Hard Rubber **cap** for single Electric Light Terminal (fig 48) inside diameter	ragout.
Hard Rubber **cap** for tubular telephone terminals (fig. 27a) inside diameter	ragweed.
Carriers for erecting aerial cables (fig. 64 a)	raiment.
——**Cents** per foot of cable	rainbow.
——**Cents** per foot of conductor	raisin.
——**Cents** per pound	rakish.
——**Cents** per foot of duct, F. O. B.	rally.
——**Cents** per foot of duct, including laying	ramify.
What grade of rubber **compound** ?	rampage.
Sterling rubber **compound**	ramparts.
Tip Top rubber **compound**	ramrod.
Rubber compound having ——per cent of pure para rubber	ranch.
Conduit to be installed	rancid.
Conduit has been laid	rancorous.
Conduit laying to begin	rankle.
Conduit laying to be completed	rankness.
Conical **Connectors** (M, N, fig. 26) for conductor of number——	ransack
——Mils **diameter** over rubber	ransom.
——Mils **diameter** over braid (or tape)	ranter.
——Mils **diameter** over lead cover	rapacious.
Can you **do** better ?	rapacity.
Cannot **do** better	rapids.
Hope you can **do** better	rapport.
——**dollars** is the total amount	rapture.
Brick **handhole** boxes and covers	rarefy.
Cast Iron **handhole** boxes and covers	rascal.
Cast Iron Covers for **handholes**	rasher.
Insulation to consist of	rasp.
Insulation to consist of paper	raspberry.
Insulation to consist of one wrap of paper	ratifier.
Insulation to consist of two wraps of paper	ration.
Telephone and Telegraph **junction box** (fig. 49k)	ratline.
Telephone and Telegraph **junction box** (fig. 49 l)	rattan.
Fowler-Johnston Telephone **junction box** (fig. 49m)	ratting.

Manhole covers..... ravage.
Manholes to be built..... raven.

NAMES.—(See also pages 47 and 48)

General Electric Company ..... rawness.
Postal Telegraph Cable Company..... razor.
———Street Railway Company ..... reactive.
———Traction Company..... reamer.
Western Union Telegraph Company..... rearward.

NUMERAL CODE.—(See also page 47).

00000.....din.
amperes.....kem.
inches.....sal.
meghoms per mile.....sot.
microfarads per mile.....sun.
mils.....tis.
straightaway conductors...top.
twisted pairs.....won.
volts.....wup.

If the whole **order** is placed with us..... rebel.
Combination Lamp **post**, alarm box and testing compartment, (fig. 46)..... rebellion.
Testing **post**, (fig. 47)..... recant.
Base **price**, smaller sizes at the regular advance... recanting.
Idler **pulleys** (fig. 64a) for supporting cables at cross-arms..... recipient.
Galvanized Steel **strand**..... recluse.
Switch for passing aerial cables with carriers past the messenger fastenings..... recoin.
At **temperature** of———deg Fahrenheit..... recondite.
At **temperature** of 60 deg. Fahrenheit..... recruit.
For **terms** see page 8 of Handbook No. XV..... rector.
Conference Iron **terminal**, single row of posts on each side..... redan.
Conference Iron **terminal**, double row of posts on each side..... redbird.
Hard rubber bushings for Conference **terminals**.... redolent.
Binding posts for Conference **terminals**..... redowa.
Underground Trolley **terminal** (fig. 49)..... redress.
Underground Trolley **terminal** (fig. 49a)..... redundant.
Tin in the lead cover (8 per cent if not mentioned) refection.
A coating of **tin** on the lead cover..... reflector.
If omit **tin** coating can reduce price..... reflux.
If omit **tin** alloy from lead can reduce price..... reform.
Galvanized Iron **wire**, B. B. grade..... refract.
Galvanized Iron **wire**, E. B. B. grade..... refresh.
Galvanized Steel **wire**..... refulgent.
Sterling rubber covered **wire**..... refurbish.
Tip Top rubber covered **wire**..... regal.

.....	regent.
.....	regicide.
.....	regiment.
.....	regulus.
.....	reign.
.....	relapse.
.....	religion.
.....	renegade.
.....	rennet.
.....	renovate.
.....	repent.
.....	replica.
.....	reprisal
.....	reprobate.
.....	reptile.
.....	republic.
.....	repulse.
.....	requiem.
.....	requital.
.....	rescue.
.....	resolute.
.....	resonant.
.....	respire.
.....	restful.
.....	reticule.
.....	retina
.....	retinoid.
.....	retort.
.....	revenge.
.....	reviler.

revival.
revolver.
rhapsody.
ribald.
richness.
riddle.
rifle.
rifleman.
riflepit.
rigging.
rigorous.
ringlet.
rioter.
riparian.
ritual.
rivulet.
roach.
roadster.
roaming.
roast.
robber.
robin.
rocket.
rodent.
roebuck.
roguish.
roman.
romantic.
rondeau.
ropiness.

Descriptions and Illustrations

— OF THE —

Manufactures

— OF THE —

STANDARD

Underground Cable Company.

ARTICLES

MANUFACTURED AND SUPPLIED BY

The Standard Underground Cable Company.

GENERAL REMARKS.

In order that our customers may understand clearly what articles are covered by the several price lists on pages 11 to 88 of this book, we give here a brief description thereof, showing their General Construction, Important Characteristics and advantages, the uses for which they are intended, and other details that may be found both interesting and useful.

Some of these descriptions may appear to be (and for a large proportion of the electrical fraternity are) quite unnecessary, on account of their being elementary and forming an indispensable part of the knowledge of people engaged in any branch of electrical enterprise, but our apology is, that this book will reach many people who are not versed in electrical matters, conductors or appliances and who will, therefore, welcome the explanations given of very simple matters.

No matter in what form electrical energy is utilized by man, from the transmission of tones by an infinitesimal current, to the production of light by a current of great quantity or pressure, three factors are absolutely requisite:

(a) The **Generator** or source of electrical energy at one point in the circuit;

(b) The **Translator** or consumer of electrical energy at another point; and

(c) The **Conductor** or means of conveying the electrical energy from the Generator to the Translator.

The generator may be one or more battery cells, an ordinary electro-magnet, or a dynamo; the translator may be a telephone receiver, a telegraph sounder or printer, an annunciator or call-bell, an electric motor replacing boiler and engine in a factory and replacing horses in street car propulsion, or the incandescent and arc lamps everywhere replacing oil and gas.

Whatever the generator and whatever the translator, both would be useless without the intermediary factor—the conductor, and it is with the conductor that this book principally concerns itself.

RUBBER-COVERED WIRE.

(See Price Lists on pages 11, 12, 13, 14.)

GENERAL CONSTRUCTION.

The rubber covered wire offered by us consists, first, of the conducting wire, which, unless otherwise specified in the order, will be either a single, solid conductor, or, in the case of wires and cables larger than No. 0, B. & S. G., a number of small strands—equal in conductivity to the gauge desired—so as to secure sufficient flexibility for safe and ready handling The wire or strand is tinned, as a protection against the action of the vulcanizing material necessarily mixed with the rubber compound. In the case of white or other unvulcanized core, the tinning is unnecessary, because no vulcanizing materials are used. A fine grade of rubber cement is applied to the wire or strand, which causes the rubber compound to adhere firmly to the conductor. Over this is placed, under great pressure, a

specially prepared high quality of rubber compound, the thickness of which is usually as stated in the price list, but can be made any desired thickness. In comparing prices, it is of course necessary to consider the thicknesses of the compound offered, as this materially affects the price. This compound may be uniform in color, or a white compound of the same quality is placed next to the wire, and the dark compound outside. The covering is then protected from mechanical injury by one or more braids or tapes saturated with protective compound, or it can be left plain. When no instructions accompany an order, the braided wire will be furnished. Rubber insulated lead covered cables, or cables made up of rubber insulated wires taped or braided into compact form, will be furnished upon demand, but the different requirements as to thickness of insulation on the wires. Number of wires, thickness of lead sheath, etc., are so varying that more satisfactory results will be obtained by applying to our nearest office, for price upon desired combination of wires made up in form to suit the service required. No price list of these cables has been issued, but a cable for any service, insulated with rubber, will be quoted or furnished promptly to specification.

DUPLEX WIRE.

(See Price List, page 11.)

This consists of two separately insulated wires, twisted together, thus facilitating the handling of the wires as compared with two separate single wires. The ordinary duplex wire has both members of the pair insulated with rubber and braided.

The **Marsh Duplex**, or Anti-Induction Wire, constructed under letters patent of the United States, No. 529,559, has only one member of the pair insulated with rubber, (see 1, fig. 0), and the other with saturated fiber of low specific inductive capacity, (2, fig. 0). It is thus apparent that a waterproof insulation is secured, avoiding short circuiting between the two conductors by moisture, and that the electrostatic capacity of the circuit is greatly reduced, the capacity of the circuit being the mean between that of the high capacity rubber insulation and the low capacity fiber insulation. This reduction in capacity is important and valuable in telephone circuits, and the reduced cost, with increased efficiency, is important in telegraph or electric light circuits.

USES.

Duplex wires are used for interior and out of door service for telephone, telegraph and electric light circuits. Where underground or aerial cables are used, the latter are generally extended to a center of distribution, and from this point the duplex wires are run into the buildings or offices to be reached. Where no cables are used, two wires must be provided (if metallic telephone circuits are desired) from the exchange to the subscriber. If bare wires are used, they must be crossed over each other at frequent intervals, to neutralize induction, and they are subject to interference from crosses or grounds due to the wires swinging against each other, or to broken wires falling upon others during, or as a result of, wind and sleet storms. Duplex wire of either form described herein obviates this difficulty, but rubber has a higher specific inductive capacity than fiber insulation, and is more expensive, hence for telephone service, the **Marsh Duplex Wire** is superior to the ordinary form. This wire, in single pairs, or in cables containing any number of pairs, can also be advantageously used in telephone exchanges between the distributing frame and the switch board, and to the lightning arresters, thereby greatly improving the general average of the circuits as to electrostatic capacity.

ELECTROLIER WIRE.

(See Price List, page 11.)

This consists of two rubber covered wires, (fig. 00), laid side by side and taped flat with a high grade rubber frictioned tape, which can be easily unwound to any desired distance when connecting the wires to the lamp terminals, etc.

Though available for other ordinary purposes, it is most commonly used for the concealed wiring in electric light fixtures.

"STERLING" RUBBER COVERED WIRE.

(See Price List, pages 12 and 13).

This is a high class rubber compound, containing a large percentage of pure Para rubber, and is suitable for use under any conditions for which rubber covered wires are used, and will compare favorably with the best grades now on the market, whether in tenacity or high insulating properties. By cutting off a shaving of the rubber of various wires and of ours, and comparing the elasticity and manner of breaking under tension, it will be seen at once that our compound possesses in a superior degree the qualities that a rubber covering should have, while many, if not most, others will break easily, and with a dull, lifeless, fracture.

Sterling rubber covered wire has been approved by the National Board of Fire Underwriters, and may, therefore, be used anywhere in the United States. The covering is extremely tough and elastic, and will stand where most other rubber insulations would fail. No precaution or expense is avoided to produce a thoroughly reliable and uniform product.

"TIP TOP" RUBBER COVERED WIRE.

(See Price List, pages 12 and 13.)

This is an extremely high grade rubber compound, containing a larger percentage of pure Para rubber than any other wire on the market. It possesses the qualities of high insulation, toughness, and elasticity, to an extraordinary degree, and is made for cases where an extremely high class of wiring is desired, and where the question of slightly increased cost is not material. While it is not much more costly than inferior wires sold regularly on the market, it should not be confused with such wires, as it would be unfair to compare these prices and lose sight of the question of quality. The test suggested in the previous paragraph will show its superiority, and it has also been approved by the National Board of Fire Underwriters.

USES.

Rubber covered wire is used for wiring buildings, for telephone, telegraph and electric light lines on poles, and underground (for underground use it should be lead covered), but it is more expensive than wire having saturated fibrous covering, and for telephone and some classes of telegraph service, it has the disadvantage of much greater electrostatic capacity.

Where different thicknesses of insulation are mentioned in our price list, the lighter insulations are intended for low tension current in dry or damp places, while the medium or heavier insulations are for use with high pressure currents or in wet places, and under exposure to chemical action.

It is particularly well adapted for use in plaster walls, pulp mills, breweries, abattoirs, etc., when provided with our special final covering of preservative compound.

FLEXIBLE SWITCHBOARD CABLES.

(See Price List, page 14).

Our flexible switchboard cables consist of the requisite number of very fine wires to equal the carrying capacity desired. They will be found very soft and flexible. The strands are thoroughly tinned, and then covered with rubber compound of the highest grade, and braided outside. The thickness of rubber varies according to voltage, as will be seen by reference to the price list. Special flexible cables larger than 4-0 B. & S. G. will be quoted on application, or made to order.

As the name indicates, these cables are for use in cross connecting circuits on switchboards, or elsewhere, where the wires or circuits require more or less frequent changing.

GALVANIZED IRON AND STEEL WIRE.

(See Price List page 15.)

Our galvanized iron E. B. B. (Extra Best Best) wire, is made from the finest iron, and has very high conductivity. The B. B. (Best Best) has slightly higher tensile strength, with slightly lower conductivity. Both grades are thoroughly galvanized, as a protection against the corrosive action of the atmosphere. The Galvanized Steel wire has still higher tensile strength than B. B. Iron, but slightly lower conductivity, and is recommended for particularly long spans or exposed positions.

The iron wire market fluctuates so rapidly that a list price would be misleading at the best, so it is preferred to quote on these wires upon application.

The weights per mile are subject to slight variation from list, but are very closely approximate.

USES.

These wires are used for long lines on telegraph or telephone circuits where much exposed, and where high conductivity is second in importance to tensile strength and first cost.

GALVANIZED STEEL WIRE STRAND.

(See Price List page 15.)

The galvanized steel wire strand is composed of seven galvanized steel wires twisted together to make the requisite size, and is very flexible. The tensile strength and galvanization will be found to meet the best requirements.

USES.

This strand is used to span wire for suspending trolley lines and as messenger or suspension; for lead covered aerial cables for telephone or telegraph use; also as guy wires for telegraph or other poles subject to heavy strains, etc.

BARE COPPER WIRE.

(See Price List on page 16.)

The copper wire furnished by us, whether bare or insulated, is drawn from the best Lake Superior bars, having a guaranteed conductivity of 98 per cent. of that of chemically pure copper, according to Dr. Matthiessen's standard; is drawn exactly to gauge, and is annealed in the best manner known to the art. Its conductivity is carefully observed, and our customers can depend upon receiving the best that is to be had.

We are also prepared to supply the best grades of Lake Superior Hard Drawn Copper Wire, either bare or insulated, but any orders received will be entered as for "soft drawn" copper wire, unless otherwise stated.

USES.

Bare copper wire is used extensively by Electric Light Companies operating under very low pressures, and is usually attached to glass insulators on the cross-arms or brackets of a pole line; for this purpose soft drawn copper wire is used almost exclusively, except in sizes smaller than No. 10 Brown & Sharpe's gauge.

Bare copper wire is also used extensively by Electric railroads whose currents vary from three hundred to five hundred volts, and may be considered comparatively "low pressure currents." As the trolley which completes the connection between the motor in the car and the charged wire overhead, must have a continuous rubbing or rolling contact, bare wire is an absolute necessity for the trolley wire; it is hard drawn copper, and is usually suspended over the centre of the track from supports extending out from the street curb in the form of an inverted L, or from supporting wires or cables stretched between poles on opposite sides of the street.

In the early days of street railways, it was the practice to string bare copper wires on the pole lines, or supports, along the sides of the streets, to feed the trolley wires, but the present practice is to use insulated wire, or, what is better still, and more in accord with modern progress and public demand, to lay underground cables as feeders.

Either bare or insulated (but principally bare) hard drawn copper wire is now extensively used by telegraph and telephone companies instead of iron wire for pole lines; its conductivity is

about five times that of the best grade of iron wire generally used; its breaking strength is about three and one-half times its weight per mile.

It will, therefore, be seen that the same conductivity can be secured by a smaller and lighter wire, so that either a larger number of wires can be strung on a given pole line, or a given number of wires can be strung on lighter (and, therefore, cheaper) poles or fixtures. A positive electrical advantage is also secured in the use of copper wire for telephone and telegraph purposes on account of decrease in electro-static capacity, due to reduction in section, as has been abundantly demonstrated by the lines of the American (Long Distance) Telephone Company; there is, of course, no advantage in using hard drawn copper in electric cables, as soft drawn copper gives slightly better conductivity and makes a more flexible cable.

In handling hard drawn copper wire of small cross-section, avoid sharp bends, kinks or cuts.

GERMAN SILVER RESISTANCE WIRE.

GENERAL CONSTRUCTION.

(See Price List on page 16.)

Our German Silver Resistance Wire is drawn very accurately to gauge and has a resistance of 192 B. A. ohms per mil-foot at 70 degrees F., or 21.1 degrees C. Its resistance is about twelve times that of a soft Lake Superior copper wire of equal cross-section.

USES.

Owing to its high resistance, it is used in electrical laboratories for standard resistances, and is usually attached to glass or porcelain knobs.

By winding the wire spirally on a mandril and then stretching it (after removing the mandril) so that the separate convolutions will not touch each other, a helix is produced, having a very high resistance in proportion to the amount of space occupied. Such an arrangement is used most effectively in the Cornell University Electrical and Physical Laboratories. Three sets of helices having resistances of .3, 3 and 30 ohms respectively are employed. These occupy a space about ten feet wide, one and a half feet deep and fifteen feet high. At the top they pass around porcelain knobs and at the bottom they enter a long box, where they are connected to mercury cups in such a manner that almost any resistance, ranging from a small fraction of an ohm to about 1000 ohms, can be obtained; moreover the wire is large so that several amperes can be passed through a single wire without materially heating it; hence, when a lot of the helices are connected up in multiple, quite a large current can be used. Such a system of resistances affords a ready means for the calibrating of ammeters and voltmeters, and for obtaining the characteristic curves of dynamos, etc. Where alternating currents are used, the above plan is not feasible, on account of the self-induction in the system. But self-induction is pratically eliminated by bending the wire back on itself in the shape of a letter U, and such an arrangement should alway be used for alternating currents when an unvarying resistance is required.

German Silver Resistance Wire, provided with a single or double covering of cotton or silk, is sometimes used for the same purpose as the bare wire, but its principal use when insulated, is for resistance coils in rheostats, etc., where extremely high resistances are required in a compact and portable form; in such cases, the insulated wire is neatly wrapped on small bobbins or spools, each end of the wire being connected to a binding post or contact point, so as to be readily switched or thrown into the circuit.

MAGNET WIRE.

GENERAL CONSTRUCTION.

(See Price List pages 17 and 18.)

Our Magnet Wire consists of the best soft Lake Superior Copper Wire covered with one or two very even wraps of fine cotton or silk; it is free from lumps and knots and adheres firmly to the wire; only the purest copper is used and is not sent to the covering department until the conductivity has been carefully tested, to insure its being 98 per cent. or more, and the diameter carefully gauged to insure accuracy within one mil of the standard size on all sizes larger than No. 10; on all sizes from No. 10 to No. 14, a variation of not exceeding ¾ of a mil, and on sizes smaller

than No. 14 one-half of a mil, will be allowed. Special machinery has been designed by us, to secure the greatest possible uniformity in the thickness of the fibrous covering of our Magnet Wire, and our customers can be assured that the diameter of the covered wire will not vary more than one-half to one mil from the desired diameter at any point throughout its length.

We have every facility in the laboratory at our works to make accurate tests of conductivity of Magnet Wire or German Silver Wire, and will furnish a certificate of conductivity with each reel or spool at a small extra charge; this is especially desirable if the wire is to be used as a standard resistance. Any desired thickness of insulation will be furnished, but the following thicknesses are most commonly required, in cotton covered wire, namely:

B. & S. G. No.	Single. Mils.	Double. Mils.
0000 to 00	10	20
0 to 1	10	20
2 to 5	9	18
6 to 7	8	16
8 to 9	6	12
10 to 12	5	10
13 and finer.	4.5	9

In absence of specific instructions, orders will be entered for thickness of insulation above indicated; customers should not fail to state whether the wire is to be single or double wound.

The quantity of Magnet Wire usually placed on a reel, unless a specific amount is named, is: Nos. 0 to 9 inclusive, 140 to 150 pounds; Nos. 10 to 14 inclusive, 100 to 110 pounds; Nos. 15 and 16, 65 to 70 pounds; Nos. 17 and 18, about 30 pounds; Nos. 19, 20 and 21, about 15 pounds; Nos. 22, 23 and 24, 7 to 8 pounds; smaller sizes, about 4 pounds.

USES.

Magnet Wire is used for a multitude of purposes, but its principal use is in induction coils, for telephone receivers and transmitters, telegraph receivers, transmitters and relays, and electrical instruments of various kinds; and (more particularly the large sizes) for winding armatures of motors, and of dynamos for the production of electric light currents.

INCANDESCENT LAMP CORD.

(See Price List on page 18.)

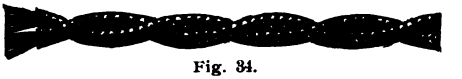


Fig. 34.

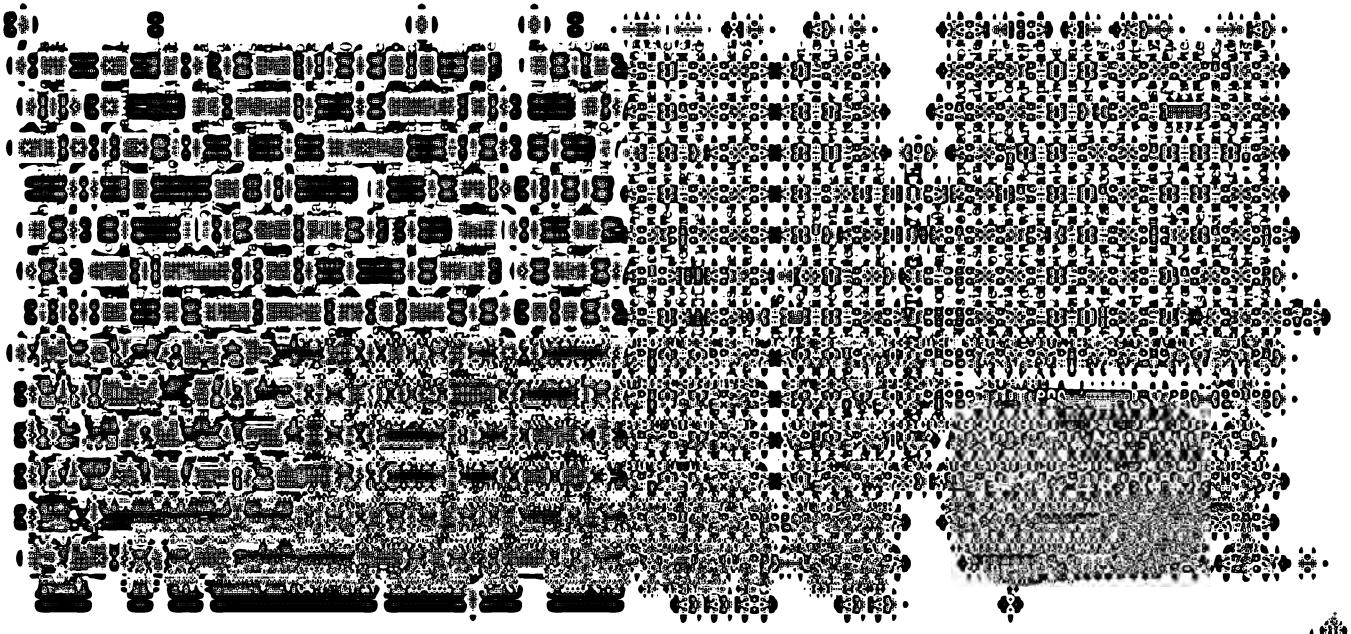
GENERAL CONSTRUCTION.

The conductor consists of a number of small strands (generally No. 30 B. & S. G.) to equal the conductivity of a solid copper wire of the size desired, about as follows:

For No. 12	B. & S. G.,	66	No. 30	B. & S. G.	Copper	Wires.
For No. 14	"	41	No. 30	"	"	"
For No. 16	"	26	No. 30	"	"	"
For No. 18	"	16	No. 30	"	"	"
For No. 20	"	10	No. 30	"	"	"
For No. 22	"	13	No. 33	"	"	"

The insulation, as will be seen by reference to the Price List, is divided into four classes:

The **first** consists of one or two dense fibrous covers thoroughly saturated with our well-known insulating compound "**Ozite,**" and will be found for all practical purposes equal to Sheet Rubber or Balata Insulation, as it is not effected by short bends, or by even higher degrees of heat than would destroy either of these; it is not absolutely waterproof, but neither is Sheet Rubber **at any time,** nor Balata after it has been subjected to moderately **high** temperatures or has become hardened by age, when it will



employment to gentlemen of the profession named; it is a fairly good wire, but has been so universally condemned and other higher grade wires can be bought at so nearly the same price, that it is rapidly falling into disuse and will eventually become a thing of the past.

USES.

Underwriters' Wire is used for electric light circuits on poles and for exposed inside wiring, for the last named purpose it is held by cleats or placed in moulding; it is almost exclusively used in white, although some times it is desired in black or brown for special locations; in absence of specific instructions, orders will invariably be filled with white wire and solid conductor.

WEATHERPROOF CABLES.

(For Price List see page 21.)

As to quality of copper, insulation and uses, see remarks under "Weatherproof Line Wire," the double covered corresponding to "Sterling," and the "triple" to "Standard" weatherproof insulation. Weatherproof cable only differs from corresponding weatherproof wires, in having the conductors made up of a suitable number of smaller wires to give greater flexibility, but not quite as flexible as switchcords. The cable form is indispensable when greater conducting capacity than 4-0 B. & S. G. is desired, and may, for various reasons, but especially convenience of handling, be required even in sizes of 4-0 or smaller, for connecting dynamos to switchboard, wiring buildings, interior conduits, etc. The larger sizes, (500,000 C. M. triple covered, being the most popular), are used principally as street railway or low pressure electric light feeders, and are furnished either with the strand "cable laid" (7 x 7), or "concentric," the latter being illustrated by the conductor in Fig. 2, page 26. The concentric form is almost invariably used; it is quite as flexible as the other, has a large margin of tensile strength, and makes a smaller and therefore lighter cable, with equal thickness of insulation. For mechanical reasons, the triple covered is recommended on all sizes, but especially on No. 0 and larger. Weatherproof cables can be furnished in any desired length, but ¼ mile is the usual length of 500,000 C. M., and other sizes in lengths relative thereto.

WEATHERPROOF LINE WIRE.

(See Price List on page 20.)

Only the purest Lake Superior copper is used by us, either soft or hard drawn according to the wishes of our customers, but, unless otherwise specified, soft drawn wire will be furnished. This copper conductor is covered with two or more fibrous covers, as will be more particularly indicated farther on.

We are sometimes met with the remark that the weatherproof wire of some other manufacturers weighs less per length than either of the grades established by us, but to all such our reply is: "We can make weather-proof wire to weigh just as light per length as desired—within a reasonable excess over the weight of the bare copper wire, which cannot vary—and all you need do, if light weight is the prime consideration, is to tell us how heavy you want it; but remember that the lighter you make it the more you weaken its insulating qualities and ability to resist rough handling or chafing, and increase the danger of crosses and accidental shocks, whether in dry or wet weather; but it is false economy, and will result eventually to the disadvantage of both consumer and manufacturer." It is wise to buy insulation as well as copper, and to buy the best that careful and intelligent methods can produce. Do not be deceived into the belief that any one can give you a lighter weight weatherproof wire without either reducing the thickness of the mechanical covering or the degree of saturation thereof with insulating compound—and both these qualities are vital; nor are there any insulating materials in use to-day that are lighter, bulk for bulk, than those used by us.

The idea of testing either Line Wire or House Wire by submersion in water with the expectation of getting high readings on the galvanometer, is somewhat ridiculous as applied to any fibrous covered wire, no matter how high a grade or how expensive a style of manufacture it may be; it has not been made for use under conditions even remotely approximating these; we are perfectly willing to make our record by the actual, practical and extensive use of our wire, both Line and House Wire, throughout every State in the Union and in almost every prominent city in any State, and upon the comparative test printed on pages 68 and 69, which has been confirmed by separate tests made since that date by

prominent electricians, who are in nowise connected with this company.

Referring to this comparative test, it will be seen that of the three fibrous covered weather-proof wires, ours stands far above the others, and that as compared with the rubber-covered wire, whether single or double braided, it was far more regular and maintained a much better average, showing great uniformity of manufacture; one sample of the rubber covered wire, it is true, showed very long life, but another sample cut from the same piece showed an extremely short life, indicating an absence of uniformity and reliability in the rubber cover.

Any reasonably well made rubber-covered wire should test admirably when immersed in water soon after it has been made, even though made of the poorest rubber compounds that could be mechanically applied to a wire, for any one having had experience in electrical matters will admit that for use under water **and to remain under water** the rubber covered wire (if the compound has not been cheapened too much) is the best, and that it will give far the highest measurements soon after its manufacture; this, however, proves absolutely nothing as to its safety and lasting qualities as a line or house wire; in order to arrive at practical results the two classes of wire (Fibrous and Compound covered) should be strung on poles side by side, and after being in practical use for, say one year, tested for insulation and mechanical properties, and, if you please, even submerged in water at that time and tested with one thousand to two thousand volt current; we are satisfied that such a test would show the fibrous covered wire to be far superior; and if such a test were made **two** years after the wires are erected, the results would show still greater superiority on the part of the fibrous covered wire. We do not pretend to sell at the price of Weather-proof Wire an article that will stand the same **water tests** as new rubber-covered wire costing a great deal more money; what we do maintain and prove every day in actual practice is that our Weather-proof and W. A. C. wires are weather-proof and water-proof enough to meet the most extraordinary emergencies to which the wires used for line and house purposes are ever subjected, and that they possess a very safe margin beyond that. These wires are not expected to be used under water for weeks at a time.

CHARACTERISTICS AND ADVANTAGES.

All our Weather-proof Wire is thoroughly saturated with our well known insulation, "Ozite" or "Waring Compound," which has for many years shown itself to be a first-class material.

In comparing our Weather-proof Wire with those of other makes, note the following:

FIRST—The fibrous coverings of our wires are thoroughly **saturated** and **not merely coated.** Wire in which the insulation is merely coated or laid on will show light gray or white threads, which readily absorb moisture from the surrounding air; if thoroughly saturated, the fiber is filled or sealed with a compound which precludes the entrance or absorption of moisture.

SECOND—The fibrous coverings of our wire are **thoroughly** saturated and not partially so, as will be seen by their perfectly black condition. The fiber that looks gray when compared with ours has not been thoroughly saturated, and, therefore, has more or less unsaturated fiber to absorb moisture.

THIRD—Every **fibrous cover** on our Weather-proof Wire **is dense and firm** and packed hard upon the conductor by special devices; examine all other wires carefully in this regard and you may find more or less open or "skeleton" braids, inside of the one outer covering, through which you can see the copper conductor; such a covering affords very little protection after the outer braid has become chafed or frayed.

FOURTH—Our Weather-proof Wire is mechanically perfect in all the foregoing respects, and the insulation presents a firm, tough mass that will stand exposure to high degrees of heat without losing its insulating qualities, and will not crack under the opposite extreme; it becomes almost as hard as iron, yet not brittle, and will, therefore, resist the maximum amount of chafing. It is easy to find so-called "Weather-proof Wire" that presents a handsome exterior finish and is "pretty" wire to look at, but give it a few bends and see the numberless little cracks or "scales" that will appear—forming passages through which moisture or rain will find its way to the fiber and to the conductor.

It is needless to name the many Electric Light and other

companies who have used our Weather-proof Wire, or to state that they are all perfectly satisfied with the service given; there is not a State or Territory, and scarcely a prominent city, in the Union in which it is not in use, and we have no reason to fear investigation or inquiry as to its lasting qualities. In the West and Northwest particularly, large quantities have been introduced, and many central station plants have been equipped with our wire exclusively; many thousands of pounds of it are also in use for inside wiring, and without any failures or trouble.

GRADES OF WEATHERPROOF WIRE.

Our Weatherproof Wire is supplied in three grades: "Sterling," "Standard" and "Tip-Top," each of which will now be separately described, the difference being substantially in the thickness of insulating covering only. Either of these wires is vastly superior to Underwriters' Wire, and our "Sterling" Weatherproof Wire is very little, if any, more expensive. It is not claimed that this wire is fireproof, but it does not easily ignite and will not transmit fire. We have always on hand a large stock of all sizes of "Standard" weatherproof line wire, and can furnish "Tip Top" and "Sterling" to order promptly.

The approximate difference in the insulation on these three grades of wire for the same size conductor (No. 6 B. & S. G.) is graphically illustrated in Figs. 37, 38 and 39.

Fig. 37.—Actual Size "Sterling" Weatherproof Line Wire.

Fig. 38.—Actual Size "Standard" Weatherproof Line Wire.

Fig. 39.—Actual Size "Tip-Top" Weatherproof Line Wire.

The approximate diameters and weights per thousand feet, and per mile, of either grade, will be found in price list, on page 20, and diameter and weight per thousand feet of weatherproof cable, on page 21, and we now add **pounds per span**, namely:

B. & S. G.	Solid Weatherproof Wire. Sterling. 125 Feet	Sterling. 140 Feet	Standard 125 Feet	Standard 140 Feet	Tip Top. 125 Feet	Tip Top. 140 Feet	Weatherproof Cables. Circular Mils.	Double Covered. 125 Feet	Double Covered. 140 Feet	Triple Covered. 125 Feet	Triple Covered. 140 Feet
0000	86	98	93	104	98	110	1000000	414	464	450	504
000	70	79	75	84	82	92	950000	400	445	432	484
00	57	63	61	68	65	73	900000	378	422	410	458
0	44	49	48	53	52	58	850000	356	398	374	433
1	36	40	40	44	43	48	800000	335	375	364	407
2	30	32.5	32	36	35	39	750000	314	352	341	382
3	24	26	25	28	27	30	700000	293	328	318	357
4	19	21	20	23	22	24.5	650000	272	304	295	331
5	15	17	16.5	18.5	18	20.3	600000	253	283	275	308
6	12	14	13.5	15.5	14.3	16.5	550000	230	258	250	280
7	10	11.	11	12.5	12.3	13.7	500000	213	239	232	260
8	8	9	9.2	10.5	10.3	11.5	450000	190	212	206	231
9	6.5	7.3	7.5	8.5	8.5	9.5	400000	166	186	180	201
10	5.6	6.3	6.2	7.	7.	7.8	350000	145	162	158	176
11	4.5	5.	5.2	5.9	6.	6.7	300000	124	139	135	151
12	3.5	3.8	4.2	4.8	5.	5.7	250000	107	120	116	130
14	2.5	2.8	3.	3.4	3.7	4.2	0000	94	106	102	114
16	2	2.2	2.4	2.7	3.	3.3	000	76	85	82	92
18	1.3	1.4	1.9	2.1	2.5	2.8	00	61	68	67	75
20	1	1.2	1.5	1.7	2.	2.2	0	48	53	53	59

For 100 feet span, point off right-hand figure of weight per thousand feet in price list on page 20, and for 10 feet, point off two figures; by adding the 10 feet weight to, or subtracting the same from, the weight per 140 feet span, or per 100 feet span, the weight per 150 feet, per 130 feet, per 110 feet, or per 90 feet will be found.

WEIGHT PER COIL OR REEL.

As a rule our Weatherproof Wire and W. A. C. Wire is packed on reels for shipment, and if the customer has any preference as to reels or coils, he should so state in his order. Some delay can be avoided at times, by permitting us to ship the wire either in coils or on reels as we happen to have it; all shipments to points west of the Rocky Mountains will be in coils, on account of the heavy freight charges which the customer would have to pay on the empty reels returning.

Following are the approximate weights per coil or per reel, that would be shipped on an order designating the wire by the coil or reel, instead of by the pound or foot, namely:

B. & S. G. No.	Weight per Coil.	Weight per Reel.
0000-0	275 lbs.	325 lbs.
1-2-3	240 "	300 "
4-5	200 "	275 "
6-8	175 "	225 "
10-12	45 "	200 "
14-16	30 "	150 "
18-20	20 "	100 "

"STERLING" WEATHERPROOF WIRE.

Fig. 40.

Where economy of construction is an important item, the purchaser some times desires to buy a comparatively cheap wire, yet with good insulation, and in order to meet this demand, we make our 'Sterling' Weatherproof Line Wire in all sizes Nos. 0000 to 18, B. & S. G.; it is only double covered, and weighs five to ten per cent. less per length (see price list) than the corresponding sizes of our "Standard" Triple Covered Weatherproof Wire. This wire is the same price per pound as the Standard Weatherproof Wire, the reduction in the cost per length being due to the smaller weight of the former.

CHARACTERISTICS AND ADVANTAGES.

The general characteristics of this wire are as described on pages 65 and 66, but the insulation is, of course, thinner than that of our "Standard" grade, and it is, therefore, less able to resist rough handling, or chafing, or moisture.

"STANDARD" WEATHERPROOF WIRE.

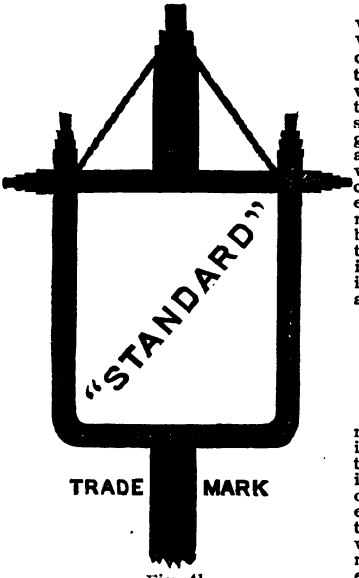


Fig. 41.

Our "Standard" Weatherproof Line Wire has three fibrous covers on all sizes this is a very high grade wire, and 90 per cent. of the Weatherproof Wire sold by us is of this grade. It has given absolute satisfaction wherever used, and cannot be excelled, either for electrical or mechanical properties, by any other wire at the same price, and is indeed equalled by few, if any. See pages 66 and 68.

COMPARATIVE TESTS.

Careful attention is requested to the following results of comparative tests made by disinterested parties without the knowledge of either of the manufacturers, on samples of wire purchased from regular stock at some electrical supply store.

The wires made by manufacturer No. 1 and manufacturer No. 8 have hitherto stood high in the estimation of the public, and are as good as the average run of Weatherproof Line Wire; what we claim is, that **our Weatherproof Wire is considerably above the average,** and the claim is justified by the tests referred to.

The tests were made as follows: A tall glass jar was filled with water, the piece of the wire under test was bent in the shape of a letter "U," with the two bared ends projecting above the jar, one of these ends being connected to one terminal of a converter giving off a thousand volts current, while the water in the jar was electrically connected to the other; at certain intervals the current was switched onto the test circuit and the effect noted; the time at which the current broke through the insulation is shown in the column headed "average life."

One of the tests included in the summary given below, consisted of bending the wire to be immersed, in a circle two and one-half inches in diameter, and another consisted in forming two such circles, each about one-half inch in diameter.

SAMPLES OF WIRES TO BE TESTED.

Manufacturer No. 1.

Sample A—No. 6 Weatherproof Line Wire.
" B—No. 8 " " "
" C—No. 10 " " "

Manufacturer No. 2.

STANDARD UNDERGROUND CABLE CO.

Sample A—No. 8 Weatherproof Line Wire.
" B—No. 10 " " "

Manufacturer No. 3.

Sample A—B No. 8 and 12 Rubber, single Braid.
" C—D No. 8 and 12 " double "
" E— No. 6 " single "
" F— No. 6 Weatherproof triple "

W. A. C. FIRE AND MOISTURE-PROOF HOUSE WIRE.

(See Price List on page 22.)

All that has been said as to the mechanical properties of our Weather-proof Wire is also true of our W. A. C. Wire, but it has a special feature in its construction that makes it far more desirable for inside wiring.

It consists substantially of our Standard Weather-proof Line Wire with the addition of a final braid of fibrous material thoroughly fire-proofed. Like our Weather-proof Wires, it is not affected, by moisture, heat, frost, alkalies or acids, but is well adapted for use where these conditions exist to an unusual degree.

Our regular stock color is a light drab, but other colors will be furnished on special orders; the conductor is composed of the softest Lake Superior copper, solid, unless otherwise ordered.

USES.

Our W. A. C. Wire is not an underground or submarine wire, nor is it intended for overhead use, being too expensive for the latter purpose; it is used for high grade inside wiring, in or under moulding or floors, in cellars, vaults, boiler rooms, etc., in short, wherever a fire-proof wire with high insulation is required. It is in use in many dwellings, churches, office buildings and municipal buildings throughout the country, and has so thoroughly approved itself to the judgment of first-class, experienced electrical engineers as a strictly safe wire for inside work, that many of them have substituted it for other far more expensive and no more efficient wires; architects and builders will do well to examine this wire and include it in any specifications they prepare.

"TIP-TOP" FIRE AND WATER-PROOF HOUSE WIRE.

(For Price List see page 22.)

Where the question of expense does not enter strongly into consideration, and where the wire is liable to become submerged in water more or less frequently or will be subjected to constantly moist conditions, our Tip-Top Fire and Water-proof House Wire is a most desirable article. The copper conductor is covered with "Tip Top" rubber insulation, perfectly applied and vulcanized, a heavy protective covering over this, and a final fire-proof coating on the outside.

CHARACTERISTICS AND ADVANTAGES.

Most rubber covered house wires on the market to-day have the serious defect of not being fire-proof, but, on the contrary, burning like tinder when a slight flame is brought in contact with the outer covering; this defect has been wholly avoided in our Tip-Top Fire and Water-proof Wire, which, as its name indicates, is an absolutely water-proof wire, at the same time that it is thoroughly fire-proof, thus combining the two important requisites of an ideal house wire.

Our regular stock color is drab, but other colors will be furnished on special orders. Soft drawn copper conductor, solid, will be furnished unless otherwise ordered.

USES.

What has been said as to W. A. C. Fire and Moisture-proof House Wire is true of this wire, while the latter is also for use in or behind plaster walls, or in any location where especially difficult conditions are to be met, such as continual dampness or occasional submersion in water.

The Standard Underground Cable Company's Electric Cables,

FOR ALL ELECTRICAL USES, UNDERGROUND, AERIAL AND SUBMARINE.

SOLE PROPRIETORS OF THE "WARING" CABLES.

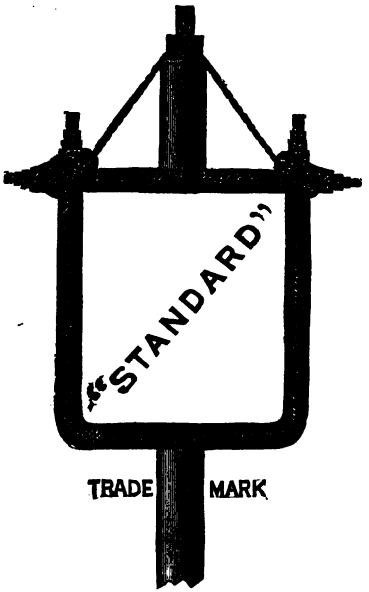


Fig. 43.

General Remarks.

One of the most interesting as well as troublesome problems that the Electrical companies have had before them in recent years, has been that of placing conductors underground for conveying electrical currents of all kinds. The history of invention presents a long line of unfortunate projectors who have grappled with the question in vain; many of their devices were so impracticable that they were not to be considered for a moment by any one having a practical knowledge of the subject; but others, of more skillful design, met with better success, although but comparatively few can, at this day, be cited as an evidence of the practicability of placing electric wires under ground.

The arguments in favor of the change from overhead to underground conductors are too well known to require more than the briefest mention; perhaps the strongest, from the point of view of the electrical companies, is the great unreliability of the overhead conductors, subject, as they are, to all changes of the weather, and at times entirely disabled by wind, snow or sleet, causing the entire suspension of business for hours at a time, and costing hundreds of thousands of dollars annually for repairs. Viewed from a public point of view overhead wires are also objectionable—disfiguring the streets, obstructing firemen in their duties, and constantly menacing life and limb. The contrast between the appearance of the same street with overhead wires and with underground cables is graphically shown in Figures 44 and 45, the former being from an actual photograph. (See pages 72 and 73.)

Mr. Alfred Shaw, the well-known writer on Municipal Government, in the article, "Notes on City Government in St. Louis" (*Century Magazine*, June, 1896), speaks of the maze of overhead wires as "the one remaining disgrace of the streets of St. Louis" and adds, "no other great city in the whole world now permits electric wires to be strung overhead in the central business streets. * * * * Everyone acknowledges that these poles should be abolished, and that the wires should be placed under the sidewalks or roadways."

It can be mathematically demonstrated that in the long run, allowing for the serious interruption to, and expensive renewal of, regular overhead lines, it is cheaper to lay underground or string aerial cables, even where only a moderate number of wires is involved; and where the wires are very numerous, the actual first cost alone is less. (See tables on page 180.)

with the best interests of the electrical companies. A complete system of underground cables is the best guarantee of the practical control of the telephone business, even after controlling patents shall have expired; in other words, given an existing telephone company doing business with overhead lines and a new company enter the same field with all its lines underground, the public will not be slow to choose the latter; first, because as a body the public is opposed to overhead wires, for well known reasons, and second, because the companies whose wires are all underground, will be certain to give constant and uninterrupted service, whereas with overhead lines every storm of any magnitude results in open, crossed and grounded wires, to the great annoyance of the subscriber. Both Telephone and Telegraph companies—especially in the larger cities of the United States—keeping up with the progress of the times, are busily engaged in putting their wires underground, partly in deference to public demand, but principally because it is a positive advantage to them; it results in a great saving in the cost of maintainance, absence of interruptions to service, and puts them in a commanding position to control the business of the future.

ELECTRIC LIGHT SERVICE.

Electric Light companies throughout the United States are spending much time and money in underground cable work, and few cities of any prominence are now without electric light systems operated through underground cables. The feasibility of this method from an electrical and commercial standpoint, at least for large cities, has been fully demonstrated by the prominent companies of New York, Boston, Philadelphia, Washington, Pittsburgh, Chicago, Minneapolis, and elsewhere, during the last five to ten years; that the interests and safety of the public would be subserved by placing all electric light wires underground in the more important parts of large cities, where wires are numerous, no one will doubt, and electric light companies themselves now realize that even from a financial standpoint it is an advantage to them in such localities because of the great saving in repairs and renewals, freedom from interruption of service, and from damage suits for injury to persons and property.

Mr. C. H. Wilmerding, General Manager of the Chicago Arc Light and Power Company, referring to the larger cities, says:

"The forests of poles and net work of wires are unsightly. The number of wires becomes so great, that there is confusion and danger at all times; and during storms serious accidents are almost certain to occur. Here the public good requires that they should be underground, where, notwithstanding Mr. Edison, they are much safer; but here also there is the demand, and even the absolute necessity for the electric light, which insures a fair profit upon the investment, so that with good management there is no reason why underground high tension wires cannnt be operated in large cities with success and profit."—*Electrical Industries, January, 1890.*

ELECTRIC RAILWAY SERVICE.

Electric traction has made wonderful strides in the past seven years and to-day very few cities in the United States use "horse flesh" in the propulsion of street cars. Branch lines of some steam railroads have been "trollied" and the possibility of the Electric Locomotive for main lines will soon receive practical demonstration.

The trolley wire of electric railroads (see page 59) is of necessity a bare wire, and on this account, coupled with the fact that the voltage is not so high as to be seriously dangerous, their wires have been tolerated overhead, but the projectors of electric railroads should read the "signs of the times" and profit by the experience of the electrical companies in New York City. Overhead wires will not much longer be tolerated in any large city.

But, if the electric railroads place their feeders underground in the first instance, they may delay a final clamor for underground trollies which is imminent in view of the practical demonstration, during the last twelve months in New York and Washington City, of the practicability of the underground trolley.

The electro-motive-force of the current used in operating electrical railways is so low that the undergrounding of the main or feeder wires presents no difficulty whatever, whereas their presence overhead presents many objections; in the case of roads now or hereafter to be equipped, true economy requires that the feeders be placed underground.

STEAM RAILROAD SERVICE.

Of all the great industries of the country which suffer from an interruption of telegraph facilities, none, probably are so de-

pendent on continuous and certain means of communication, as the railroads; with every storm of any degree of severity or extent of area, the lines are interrupted and the block signal systems disabled, with consequent obstruction and danger to passenger and freight traffic. The importance of uninterrupted communication between the trainmaster's office and the various telegraph or signal stations along the road cannot be overestimated. The attention of railroad managers is particularly asked to the Standard Underground Cable Company's Cables in this connection, and to the ease and certainty with which their wires may be placed beyond the reach of such dangers, and the operation of their roads beyond the caprice or power of storms, etc. Railroad managers are beginning to appreciate the value of underground cables, especially where they have many telegraph lines converging, as in the larger cities, and through tunnels, where exposed wires are quickly destroyed by the action of Sulphuric Acid contained in the coal smoke. As a rule, the overhead wires, instead of passing through the tunnel, are led over the hill-top or mountain by circuitous routes, where they are especially liable to interruption and destruction by rain, snow and wind storms, and are far more difficult to repair than at any other part of the line, if indeed not wholly inaccessible at times. The simple expedient of laying a cable in the tunnel or snow-shed, obviates all these difficulties and dangers; and the Standard Underground Cable Company has been successful in this line, as is shown by the many cables now in use in tunnels and by the electric light installation in the Hoosac Tunnel, where the most difficult conditions are successfully met. (See Scribner's Magazine for August, 1889.)

MINE SERVICE.

In mining operations it is extremely important that signals shall be transmitted with certainty and rapidity from the various parts of the mine to the engineer at the mouth of the shaft, and that light and power shall be supplied at the minimum cost and maximum safety, to any desired part of the mine; for this purpose electricity is far better adapted than purely mechanical devices; as a rule, the steam plant of mines exceeds the actual requirements, so that it is a matter of economy to supply light and power by electricity, the engineer in charge being generally able to take care of the electric light plant without further assistance. The old method of lighting mines constantly leads to great loss of life and property; incandescent lamps cannot cause explosions, first, because the filament is hermetically sealed in the glass bulb; and second, because the moment the glass is broken, the filament is destroyed. Steam or compressed air for operating pumping, hoisting and drilling apparatus in mines will vitiate the air and rot the timbers, while candles or lamps consume the oxygen in the air, thus rapidly undermining the health of the workmen. The vast improvement and economy from a financial and hygienic point of view, made possible by the introduction of the Electric Light and Motor in mines, merit the closest study of mine owners and operators. The importance of uninterrupted transmission of signals, light and power is so great, that the question of the excess in the cost of lead covered electric cables over that of bare or insulated wire is not worthy of consideration. Lead covered cables are absolutely safe for conveying the electric current for either of the purposes here named; they are flexible and can be laid to any portion of the mine.

The Standard Underground Cable Company has spared no effort or money to produce a cable that will meet every condition that obtains in practical work, and to this end it has for many years past had in its employ the best mechanical and electrical experts that could be procured. It is largely due to this policy that the Company to-day stands in the forefront of progress in the manufacture of Underground Cables

The **"WARING" LEAD COVERED CABLES** are in daily use all over the United States, and for every conceivable electrical service, many of them have been in successful operation for a period of thirteen years; no other company has had the varied, extensive, and withal successful experience that we can point to. When you buy our cable you buy an article that has proven itself worthy of public confidence, and from a company that has a reputation at stake, which it would not impair by careless or imperfect workmanship, and that is financially responsible and able to carry out any obligations that it takes upon itself.

We have successfully met all conditions and difficulties, and have devised and perfected many desirable devices and accessories comprising a complete system, of all of which our customers get the benefit.

The most important features of an underground cable are:

FIRST—Its Insulation.

SECOND—The Protective Covering to guard that insulation against deterioration, from either chemical, mechanical or atmospheric actions.

INSULATION.

By far the most important feature in an underground cable is the insulation, and it was to this that attention was first turned, with the result of securing a compound known as "Ozite" or "Waring Insulation," having a specific inductive capacity more closely approximating that of air than any other insulating material known, together with the highest possible insulating qualities. This compound is an inorganic substance, and there is therefore no need to fear deterioration from time and use. This is abundantly proven by the Waring Cables that have been longest in use—some about thirteen years. Another prime quality is that it can be safely subjected to high temperatures, thus making its use possible adjacent to steam-heating pipes, whether under the streets of a city or inside of buildings, a feature that is not possessed by either paraffine, rubber, gutta percha or rubber compounds. "Ozite" or "Waring Compound" is covered by patents owned exclusively, and can be used only, by the Standard Underground Cable Company; it is a hydro-carbon compound. By the use of "Ozite" the insulation of our cables is made uniform in quality throughout their entire length, the measured resistance ranging from 2,000 to 5,000 megohms at 60 degrees F. depending inversely upon the size of the conductor and directly upon the thickness of the insulating covering. The low specific inductive capacity of "Ozite" is an extremely important and advantageous feature; the lower the capacity of a telephone cable, for instance, the more distinctly will the tones of the voice be transmitted, or the greater the distance over which it is possible to carry on conversation; the lower the capacity in a telegraph cable, the more rapidly and certainly can signals be transmitted, or the greater the distance such signals can be transmitted without relaying or repeating; the lower the capacity in an Electric Light Cable (without air spaces) the less the danger of a disruptive discharge from conductor to earth through the insulating covering. The relative specific inductive capacity of various substances is shown on page 158.

The heat resisting point of "Ozite" is extremely high, very much above the point at which gutta percha, rubber compounds, paraffine, and most other insulating materials, except glass, would be rendered absolutely valueless; this is an important point, and one that should not be overlooked by any one purchasing cables to be laid in the streets of a city adjacent to steam-heating pipes, or where, at any time in the future, such pipes may be laid in close proximity to the underground cables.

Assistant General Manager A. S. Brown, of the Western Union Telegraph Company, says:

"We required a cable that, while filling our requirements as to insulation and conductivity for our high tension currents, would also withstand the heat from the steam heating pipes. AFTER MANY TESTS WE DECIDED TO USE THE WARING CABLES."

And since then, and recently, he has said:

"At last we have been able to get a cable (namely, the Waring Cable) to work in these ducts."

Our regular "Ozite" will not run at 200 degrees or about the boiling point of water. Where cables are to be laid in close proximity to steam heating pipes, we vary the constituent parts of "Ozite" so that it will not soften short of 175 degrees and will not become liquified short of 250 degrees. This cannot be done with any other known insulating compound at the present day. Even when heated to the maximum, the conductor cannot decentralize, as the compound is only used to saturate and hermetically seal the dense fibrous coverings placed upon the conductor.

Insulated wires and cables are divided into two broad classes with respect to the materials used for covering the wires, namely:—Fiber insulation, in which yarn or paper tapes are used, and Solid, in which rubber or gutta percha compounds are used.

FIBER INSULATION.

In the process of making the Waring cables of this class, the wires are thoroughly covered to the desired thickness, with yarn or a special paper, the desired number of conductors is assembled into a single compact core (see page 81), all moisture is expelled from the fibrous covering, and, except in the case of dry core cables for telephone use, the fiber is thoroughly filled with "Ozite." Cables so made are not of themselves waterproof, but the addition of the lead cover makes them so. The ends, of course, must be protected against moisture, but that is accomplished in so easy and rational a manner, as explained under "Terminals" on page 89, and the terminals are so desirable, convenient and inexpensive an addition to any class of cables, that this constitutes no drawback whatever. For many purposes, the insulations, which are in themselves waterproof, namely, rubber compounds, or gutta percha, are entirely unavailable or objectionable on account of their high electrostatic capacity, as, for instance, for general telephone use, or for duplex or quadruplex telegraphy, and for A. C. lighting. Moreover, lead covered underground cables whose insulation is relatively an absorptive one, have a practical advantage over those otherwise insulated, in that, when a serious injury occurs to the lead cover, the insulation decreases only *gradually*, and the cable does not become *entirely* disabled and unavailable for service for three to six weeks after the injury occurs, thus giving notice that an injury has occurred, and ample time to repair it before the cable is wholly unfit for service. In one case a street railway cable remained in service over a year after the injury occurred, and in another case a telegraph cable used under water had a hole gouged through the lead cover by an ice gorge, and yet two or three weeks after the accident only a few of the wires had failed or showed low insulation, and the damage was repaired by cutting out only six inches of cable and resplicing it. In the case of rubber or gutta percha insulation, the destruction of the lead cover is followed by the rapid deterioration of the insulating covers by earth gases, etc., but the insulation tests will not indicate this until the rubber is destroyed through to the wire, whereupon it will burn out or become grounded suddenly, and without any warning or opportunity to repair the injury. Practical men will appreciate that this means loss of service just when it is most needed, with consequent complaints and claims for rebates on bills. The fibrous insulation resists compression far better than rubber. In bending rubber insulated cables around manholes, the rubber is both stretched and compressed and so made thinner than normal; hence experienced engineers require such cables to stand a test pressure 25 to 50 per cent. in excess of that required for fiber insulated cables. Our fiber insulated cables have given continuous satisfactory service since 1882, and can be relied upon in every respect.

RUBBER INSULATION.

The superiority of our rubber compound has been fully pointed out on pages 56—58, and special care is used in the manufacture of our rubber covered cables. Any desired number of rubber covered wires, prepared as there explained, is assembled into a single compact core or bunch (see page 57) and if intended for overhead or house use, the bunch is thoroughly taped over with one or more layers of strong, closely woven compounded tape. For use underground, such cables should be protected against atmospheric action or acids, by a lead cover, and the ends by terminals as explained on pages 88 to 91.

Before lead covered cables were made in this country and elsewhere, rubber or gutta percha insulated and thoroughly taped and compounded cables, without lead covers, were used for underground service, but after many years of futile and costly experiment, there is scarcely a single cable of this kind in successful operation at the present day, except submarine armored cables; but lead covered cables rapidly replaced the non-leaded type, and it is now the practically unanimous judgment of experienced practical men that no cables should be laid underground without a lead cover. If kept constantly immersed in water, and not exposed to acids, gases, street drippings, etc., and not subject to extreme changes in temperature, or to high temperatures, and alternating wet and dry conditions, no better insulator can be found than rubber or gutta percha, but it is impossible to attain these conditions of safety in underground work; hence, it is a waste of money and temper to attempt such an antiquated method of construction as laying non-leaded

or tape saturated with the same compound. This fibrous cover also affords excellent protection against mechanical injury where the cables are drawn into conduits, or are otherwise subject to rough handling, although not absolutely essential.

For the simple coating of compound an extra charge of one to four cents per foot of cable is made, while for the saturated fibrous covering, the extra charge is two to six cents per foot, according to the size of the cable.

Any orders that are received for Waring Cables will be entered as plain lead covered cables, without either paint or saturated fibrous covering, unless specifically stated.

In telegraphing orders for cable that is to have the protective coating, use the proper code word on pages 40 and 54b.

Most of the cables sold by this company to Electric Light and Telephone companies in New York City, and to the Electrical Bureau of Philadelphia, have this saturated fiber over the lead, and it serves its purpose completely; cables that were merely coated or painted and placed in creosoted conduits in Philadelphia nearly four years ago, show no trace of chemical actions or deterioration of any kind, while a lead encased cable whose sheathing was alloyed with a percentage of tin was laid in the same way, and was found to be covered with a white coating to a considerable depth after being in the duct but three months.

A careful examination of the braids or tapes on our cables will show thorough saturation and adhesion to the lead cover, and instead of the compound being dry, granulated and powdery, so as to rub off and smut the fingers (as is the case in many cables), our compound will be found to be almost as hard as iron, tough, and homogeneous throughout. It is the difference between perfect materials and careful and intelligent workmanship, with the prime object of producing a strictly first-class article irrespective of cost, and the opposite.

TIN IN THE LEAD COVER.

Sometimes we are asked to furnish cables having a percentage of tin in the lead cover, and while ready to do so if insisted upon, yet it is a futile attempt to prevent chemical actions, and needlessly increases the cost of the cable.

Lead pipe containing any percentage of tin from 1 to 10, was made as early as 1867. Numerous careful chemical analyses confirm the statement of experienced manufacturers of lead pipe, that it is not commercially possible (as it might be in a laboratory retort) to produce an absolutely uniform alloy of lead and tin, and this is now recognized by prominent telephone companies, whose specifications allow a variation of 1% in 3, fixing the minimum at 2½ and the maximum at 3½%. The mixture of 3% of tin, does not afford the protection sought, and it is a decided disadvantage in that it makes the lead covering brittle, and, therefore, liable to develop cracks.

As the result of careful study of this subject we commend our patented (Jan. 1, '89) coating of

TIN ON THE LEAD COVER.

After the lead cover is applied to the wires, a suitable flux is first applied to its surface, in order that the molten tin, through which it is then drawn, may adhere firmly to the lead cover of the cable. Special machinery was designed and built by us to carry out this process with the greatest certainty and perfection. It needs no argument to convince the intelligent reader that this way of using the tin is sensible and practical, and "puts the right thing in the right place." Many of our customers have adopted this coating instead of the lead and tin alloy, and with uniformly satisfactory results. In some cases, the saturated braid, above mentioned, is applied in addition to the tin coating or tin in the lead, but in New York City the tin coating has superseded the saturated braid entirely.

Tin is much less oxidizable than lead or iron, hence such a coating applied to the lead cover, presents a uniform surface better adapted to resist oxidizing agents. It is also harder than lead, hence will better resist abrasion. It is both harder and smoother than lead, and is, therefore, more easily drawn into and out of conduits, which is especially important when the conduits contain more than one cable. An extra charge is made for the tin alloy or the tin coating, and neither will be furnished unless specified in the order.

CLASSIFICATION.

The Cables manufactured by the Standard Underground Cable Company may be classed under the following heads, indicating their form or general construction, and the purpose for which they are used, viz:

Anti-Induction Cables, for Telegraph, Telephone and General Electrical Uses.

Bunched Cables, for Telegraph, Telephone and General Electrical Uses.

Electric Light and Power Cables, for Arc and Incandescent Lighting, and for Power.

Submarine Cables, for any of the purposes above enumerated.

A classification based on the locations in which the cables may be used would comprise, **House Cables, Aerial Cables, Underground Cables, and Submarine Cables.**

These cables will now be described in detail.

The WARING ANTI-INDUCTION CABLES.

(See Price List on page 29.)

These are made up in various forms (see page 28 for some of them), and may contain any required number of conductors within the limits indicated in the Price List. Whatever the form of cable or number of conductors, the principle of construction is the same. The conductors are covered with fiber to the desired thickness, all moisture is expelled and the fiber is thoroughly filled with "Ozite;" the conductors are then enclosed in a continuous sheath of lead pressed closely around and between them, so that each conductor is separated from every other conductor by a metallic sheath, as shown in the illustrations.

This form of construction serves to shield each conductor against induced currents from adjacent parallel conductors, thus obviating the annoying effects of induction or "cross-talk," on telephone circuits, which will be appreciated by all users of the telephone. It will be observed that one of the corrugations of each cable shown in figures 9 to 12, page 28, differs in cross-section from the others, being provided with a sharp edge or corner. This serves to designate the position of one particular conductor throughout the entire length of the cable, so that it is a simple matter to select any conductor in the cable, and extend it into a branch office, or signal or alarm box, or to a subscriber, or for making a splice, without disturbing the others.

This class of cables, with its special marking feature, (covered by patents owned by this Company,) is especially valuable to Fire and Police Telegraph Departments, who are required to have a number of signal or alarm boxes, or Patrol Stations, on each circuit, and the facility of selecting the desired conductor to "loop out" at any point without in the least opening or interfering with any of the other operating circuits in the cable, is not the least important feature in these cables. The price list is for "Standard" insulation, by which is meant insulation of such thickness as to give the following diameters, including conductor and insulating covering, viz: No. 10—220 mils; No. 12—185 mils; No. 14—156 mils; No. 16—130 mils; No. 18—120 mils; No. 20—105 mils; No. 22—100 mils. Prices will be quoted on application, for any desired thickness of insulation.

Among the prominent users of the Waring Anti-Induction Cables for Telegraph, Telephone, Fire Alarm and Police Telegraph purposes are the National and District Governments, of Washington, D. C.; the National Government at its Torpedo Station, at Newport, R. I.; the Fire and Police Telegraph Departments of New York, Philadelphia, Buffalo, Pittsburgh, and elsewhere, and Telegraph Companies in New York, Washington City, Pittsburgh, etc.; the Union Switch and Signal Company in block signal systems, and many Iron and Coal mines throughout the country.

An important and now commonly used form of anti-induction cable is the "Twisted Pairs Cable" described on the next page. It, too, prevents "Cross-Talk" and is less expensive and bulky for the same number of conductors and is therefore preferred when duct space is limited or costly. It does not, however, afford the same facility of selecting and looping out wire without interfering with others in the same cable, that is afforded by our special forms of page 28

THE WARING BUNCHED CABLES.

FOR UNDERGROUND, AERIAL, OR HOUSE USE,

are illustrated and listed on pages 80 and 81. They are composed of any desired number of conductors up to a maximum of say 200, each of which has been separately covered with yarn, or specially prepared paper tape to the desired thickness, and then assembled into a core or bunch held in shape by a close covering of yarn or paper, and the whole enclosed in a continuous lead cover, as explained on page 78. In all but dry core cables the cores are thoroughly saturated, and the lead sheath filled with our celebrated "Ozite" compound. When paper of the proper quality is used, a stated thickness gives a lower electrostatic capacity than yarn, and of either class the unsaturated dry core gives a lower capacity than the saturated, hence the tendency in telephone cables has been to employ paper as the insulating medium, and to leave it unsaturated when for underground use where the cable is but little liable to interference or injury, while for more exposed service, such as aerial cables, and even sometimes for the distributing cables from underground main cables to the terminal, they are more generally saturated; where long distance service is the controlling factor, or where the same cables are to be subsequently used underground, the overhead cables are also made dry core. The advantages in favor of saturated core are that if the lead is injured, only a small portion of the cable (sometimes only a few inches) will be lost, and the injury may be discovered and repaired while only a few of the circuits are disabled, whereas a dry core cable, under the same circumstances, would absorb moisture, and consequently need replacing, throughout a whole section between joints, and the circuit would be lost more suddenly, and most likely every circuit in the cable would be lost before the repairs could be effected. These are serious drawbacks, and hence for overhead use, where cables are much more liable to injury than underground, saturated cables are generally preferred at the sacrifice of the lower capacity. For capacity of overhead wires, see page 174.

The locating of faults, (See pages 140 and 142) on yarn or paper insulated cables, is greatly facilitated by our Fisher patented method of including in the center of the bunched cables, or in the outer layer of Strands of Electric Light Cables, for the "Loop" method of locating faults, one or more small rubber insulated test wires. These will not be furnished unless specifically ordered.

In Bunched Cables of the ordinary form—sometimes spoken of as "straight wires," or "straightaway" cable, to distinguish them from twisted pairs cable—the insulated conductors are laid up compactly and with the greatest regularity, in series or layers, the number of conductors in each layer increasing, of course, from the centre outward. The advantage of this is, that if a given connection is desired, whether for loop, branch, terminal, or splice to the next section, it can be made with a minimum number of test-calls, and much time and labor thereby saved; this advantage is still further enhanced by varying the outer fibrous covering of one of the conductors of each layer (for instance, a braid instead of a wrapping) to serve as a marker or starting point, from which to count to the right or left to the particular conductor which it is desired to reach.

A form of construction which has come into general use for telephone circuits, is that known as "twisted pairs," the conductors of a bunched cable being first twisted upon each other in twos, all these pairs bunched together as in "straightaway" cables, and the resulting bunch or core provided with a lead cover. Each twisted pair constitutes a "metallic circuit" from the exchange switch-board to the subscriber's telephone, and as each leg of the circuit is subject to the same influences from the adjacent conductors—occupying exactly the same position relative thereto—a complete neutralization or balancing of inductive interferences is secured. If the twist is short, say one in three or four inches, there is absolutely no cross-talk whatever.

As metallic circuits for each subscriber will doubtless be required in the near future, we recommend the purchase of twisted pairs telephone cables, even though they are to be used on the earth return or common return plan. For if driven to metallic circuit service, these cables are available for it, and in the meantime are equally available for the other plans; whereas, straightaway cables could not be used satisfactorily for metallic circuit ser-

vice. Furthermore, if the cable is for a common return telephone system, we recommend the system patented by us, namely: to have twisted pairs cables and use some of the pairs (whether of a size uniform with or larger than the regular circuit pairs) as common returns, and then when metallic circuits are adopted the returns are equally as available as the other pairs in the cable, to supply a subscriber, and if the return pairs have been made larger than the regular pairs, they can be assigned to the subscribers farthest from the exchange.

Telephone cable specifications vary to some extent, but the most usual are as follows:

Conference underground cable, No. 19 B. & S. G.; copper conductor 98% pure. Insulated with two paper tapes; conductors twisted in pairs, the length of twist not to exceed three inches, and formed into a core arranged in reversed layers. Average electrostatic capacity (dry core) .08 microfarads per mile, highest .085. Insulation 100 meghoms per mile. Lead cover, 25 to 100 pairs, ⅛" thick, pure lead or with 8% of tin. The core (except two feet at each end) is generally left dry in underground cables but saturated for overhead and branch cables. Some call for only one wrap of paper and for No. 18 conductor, and for overhead cables No. 20 and No. 22 are often used, as also a saturated braid over the lead, and the lead sometimes only $\frac{1}{64}$ inch thick. The capacity requirements vary up to .10 microfarads for dry core, and to .18 for saturated cores. For underground use in very large cities, we advise the regular conference cable, but elsewhere we recommend our

NEW STANDARD TELEPHONE CABLE.

No. 19 dry for underground, and No. 20 saturated or dry for overhead, copper 98% pure, two wraps of paper, conductors twisted in pairs and laid up like conference cable, a paper cover over core; pure lead cover $\frac{1}{64}$ inch thick on 10 pairs to $\frac{1}{16}$ inch on 100 pairs and a closely woven saturated braid over the lead for aerial cables, but slightly thicker lead without the braid for underground cables. Capacity average .095 dry and .15 saturated. Insulation 100 meghoms per mile. All tests at 60° Fahrenheit.

When underground cables are to be laid under circumstances where there is danger of chemical actions, they should have a saturated braid over the lead, or at least a thorough coating of anti-corrosive compound.

Our price list of Bunched Cables applies to "Straightaway" Cables, that is, wires laid up in the ordinary way, not twisted in pairs, and has reference to "Standard" insulation, by which is meant such a thickness as will give the following diameters for each conductor of the sizes named, including the conductor itself and the insulation around it, namely:

No. 10—180 mils; No. 12—160 mils; No. 14—136 mils; No. 16—120 mils; No. 18—105 mils; No. 20—90 mils; No. 22—85 mils.

If thicker insulations are required, it must be so stated in the order, and in case of telegraphing, use code word "oarweed," followed by the proper syllables selected from "Numeral Telegraph Code," page 47.

Bunched Cables, whether twisted pairs or straight wires, will be provided with comparatively light lead sheath if for "aerial" or "house" use, but with heavier sheath if for underground use, and with an extra heavy sheath if for submarine use, the cost varying with the thickness of the lead cover.

As in every other branch of our business, we have aimed to attain the highest possible perfection in the manufacture of our Bunched Cables; it is generally conceded that their mechanical construction is unequaled—certainly unexcelled—by anything in the market to-day, and those who have given them careful trial in comparison with similar cables of other manufacture, know that the same is true of their electrical properties.

Our Bunched Cables have been in successful use by all the Telegraph and most of the Telephone Companies throughout the country, underground and overhead, for various periods up to fourteen years, and we invite the most stringent investigation of their merits.

HOUSE CABLES.

Our Anti-Induction, Single Wire and Bunched Cables, with **Light Lead Cover** are also used for all classes of house work, where permanent and reliable wiring is desired; they frequently

replace the ordinary braided "Office Wire Cables" in locations where a large number of circuits are to be laid, as for instance, to hotel annunciator, etc.; ordinarily, and preferably, the conductors of these cables are insulated with "Ozite" as in underground cables, but where specially desired we will furnish Bunched Cables with paraffine insulation and in the usual Annunciator Wire colors.

The Flat Cables (see Figures 4, 11, 13, 14, 17 and 18) are especially adapted for house use, as they have rather an ornamental appearance when placed on the wainscoting and stained and varnished, this being a very desirable feature in wiring a house which was not provided with wire-ways or conduits when built.

All dealers in electrical supplies should carry a full line of these small cables, say 1, 2, 3 and 5 conductors, for they represent but a small investment of capital and are sure to find ready sale if on hand for immediate delivery. Innumerable houses have been fitted up with them, and a case of deterioration or failure has never been heard of. In connection with the wiring of houses, it is easy for an energetic dealer or contractor to sell a lead covered underground cable for connecting residence with stable, as no man in moderately good circumstances would allow his house and grounds to be disfigured by the presence of overhead wires, when at a comparatively insignificant expense they can be buried out of sight and out of danger of interruption or destruction by the elements. In many cases the mere suggestion will lead to an immediate sale. See Working Directions.

ELECTRIC LIGHT AND POWER CABLES.

(See Price Lists and Illustrations pages 23 to 27.)

In no branch of electrical conduction, by means of underground cables, have the conditions been more drastic than in that of electric lighting with high tension currents, for the reason that the electric current to be conveyed has far greater pressure (and, therefore, much greater tendency to disrupt the insulation and escape from its conductor) than any other current in practical use at this time; great difficulties were encountered, some failures were experienced (due principally to inexperience or utter disregard of ordinary care on the part of those in charge of the laying jointing or operating of the cables), but in each case these only led to a better understanding of the conditions to be provided for and to the invention or adoption of the means of overcoming them.

Mr C. H. Wilmerding (see foot note, page 78) aptly expresses the situation when he says:

"Experiments and a certain number of failures must necessarily go before success in anything. Experiments are expensive and failures (except where they are anxiously prayed for) are discouraging, but without them electricity would not be the agent it is to day, and where this subject has been taken up seriously and with intent to overcome every obstacle and to succeed, results justify the statement that in this field of electrical progress, as well as in the rest, 'there is no such word as fail.'"

Mr. Maver (see last paragraph page 72) says in *Electric Power* for April, 1895:

"There were cable manufacturers in this country who stood ready at the time mentioned (1888) to guarantee their cables for use on high potential circuits in the underground subways. For instance the STANDARD UNDERGROUND CABLE COMPANY * * I might further add that the cables then furnished together with hundreds of miles of similar cables since furnished, are still in successful operation in the New York and other electrical subways."

The Standard Underground Cable Company will furnish, install and guarantee its underground cables to carry current of any voltage desired, but the customer should consider (and state) the conditions under which the cable is to be used; if for underground use, into what kind and size of conduits is it to be drawn, or if not to be drawn into conduits, what kind of protection will the cable receive, and in either case, is there any danger of chemical actions, either from the character of the adjacent soil, from illuminating, or sewer gas, or from acid works, etc., along the line of trench or conduit,; also how many volts and amperes are to be transmitted through the cable and what kind of dynamo will be used.

The progress made in the introduction and use of electric light and power cables has been most rapid since 1889. At that time it was conceded that low tension electric lighting or other

service could be conducted safely by means of underground cables, but it was stoutly claimed that high tension lighting was not practicable except by overhead wires. Two thousand (2000) volts was then considered "high tension" in this sense, but the numerous and successful installations made by us for very much higher pressures since that time, have changed all this, and now it is not an uncommon thing to receive orders for cables to be operated at 5,000 to 7,000 volts, and to stand a test pressure of 12,000 volts in 1,000 foot lengths on reels. It can no longer be truthfully said that a good and sufficient insulation has not yet been found for high tension electric light currents underground.

Our electric light cables are insulated to the requisite thickness by many wrappings of yarn, or of paper tapes, applied in reverse layers, and saturated with our well-known patented insulating compound, "Ozite," which has proven its high insulating and heat resisting qualities for fourteen years past, or they are insulated with a rubber compound of a high grade. See pages 56 to 58, and 76 to 78.

While we are ready to furnish either of these insulations for any voltage, high or low, we recommend the saturated fiber (yarn) for all moderate pressures up to say 2,000 to 2,800 volts, and especially for low tension cables, or such as require comparatively thin insulation, because in all such service it represents an ample margin of safety in a practical size, it is cheaper than rubber, and less liable to crack than the thin covering of paper. Hundreds of miles of our fiber insulated (yarn) cables are in successful use in New York City, Minneapolis, Philadelphia, and many other places, for electric lighting of all kinds, and street railway service. The largest contract ever taken in the United States has been filled by us for a Street Railway Company in Philadelphia, whose underground cable purchases aggregated almost one million dollars

Paper or rubber insulation is recommended for 2,000 volts service and upwards, and especially when a working pressure of over 3,000 volts is to be sustained, and it is desired to make the cables as small as possible, these materials having a somewhat higher breaking down point than the yarn, by reason of which a thinner covering, and hence a somewhat smaller cable, suffices for the same high tension service. The rubber insulation is not especially recommended for the lower pressures, because of its relatively higher cost, nor is the paper so recommended because when applied to a less thickness than is required for high tension service, it is liable to crack when an ordinary bend is made in the cable; this is a defect in paper cables which we believe no manufacturers but ourselves have yet been able to overcome, even in the high tension cables with the thicker covering, but by the special materials used, and machinery and methods designed and built by us for this purpose, we have successfully met the problem in such cables, as is testified by the Electrician and cable superintendent of one of the largest electric light companies in the United States, who says that our paper cable is superior to all others in flexibility, and high breaking down point. Our paper cables with $\frac{5}{64}$ inch insulation, have withstood breaking down strain of 18,000 volts, which was the limit of our converter capacity.

For alternating current service, where high electrostatic capacities are objectionable, because they mean waste at the coal pile, due to increased loss by self induction, paper or yarn should always be used as the insulating medium for underground cable, since their specific inductive capacity is far below (about one-half) that of rubber or gutta percha.

Pressure wires are used in low pressure direct current lighting, to indicate and regulate at the station, the pressure existing at outlying points. A No. 14 or 16 insulated pressure wire can be easily laid into the outer layer of the Stranded cable conductor.

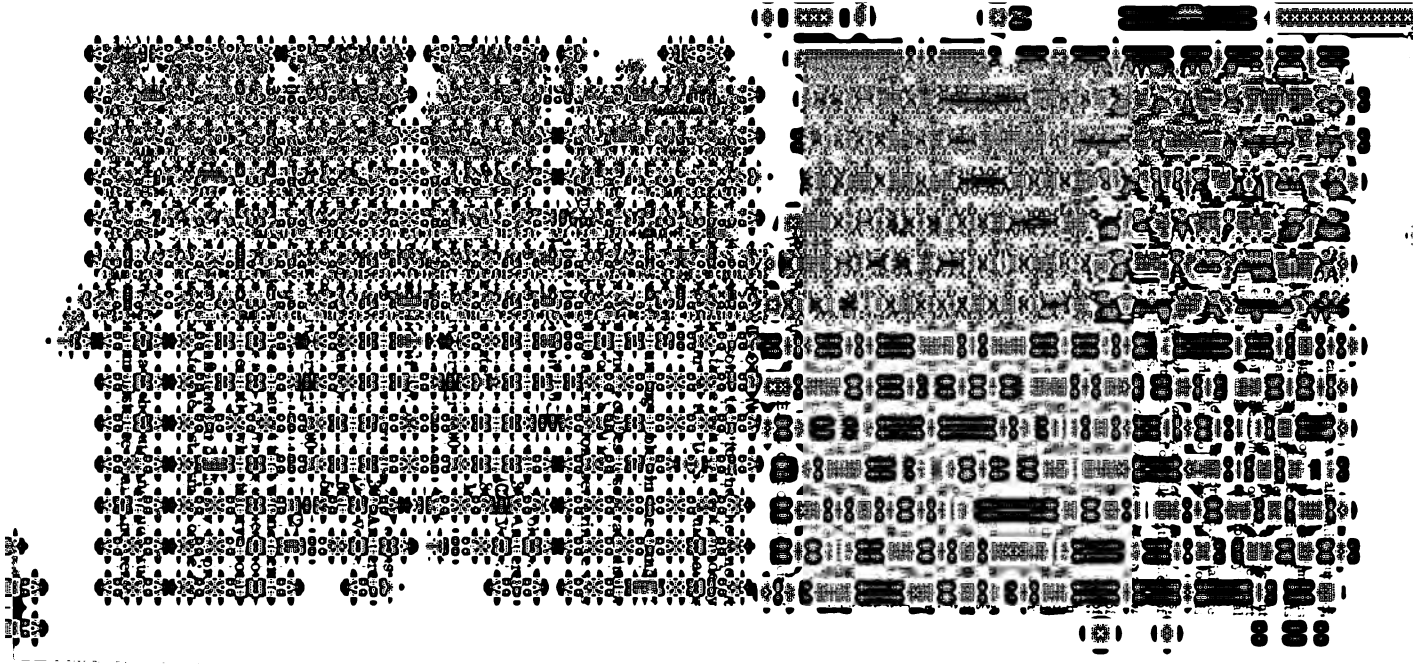
Our **Duplex (two wire) Flat Cable** (Fig. 4, page 26) is particularly adapted for alternating current circuits, as will be seen from the following letter of the well-known electrician, Mr. E. G. Acheson, and we submit it without further comment:

"PITTSBURGH, PA., May 13th, 1889

"To The United States Illuminating Company,
"No. 59 Liberty Street,
"New York City, N. Y.

"Gentlemen:

"Your favor of the 11th inst., requesting an expression of opinion on the



Duplex Cables (as well as other flat cables shown in our Waring Anti-Induction and Bunched Cable price lists) are thoroughly covered by Letters Patent owned exclusively by the Standard Underground Cable Company, one of the claims reading as follows: "An Electric Cable composed of a series of insulated wires in the same plane and inclosed by a close-fitting flat flexible lead pipe;" and the special marking feature to distinguish between conductors in the same cable, or between several cables drawn into the same duct, is also covered by Letters Patent owned by this company; but we do not take advantage of these facts or of the superior electrical properties of this form of cable to add a fictitious or arbitrary amount to its price; the price is exactly the same as we would charge for two single wire cables having the same conductor and insulation.

What has just been said of the superiority of Duplex Cables over Single Conductor Cables is also true of the **Connor Multiple Electric Light Cable** (see Fig. 8), which possesses the additional advantage of combining the maximum number of conductors under one cover for a duct of any given size, and this, in some localities, is an important consideration. Another important feature is that the conductors are flat in form (whether composed of a number of small strands laid side by side, or of a flat ribbon, or series of such ribbons superposed upon each other), and they therefore conform to the requirements of the perfect conductor for alternating currents, as determined experimentally and mathematically, by Prof. Hughes and Sir W. Thomson, whose labors in this field of research were presented by Prof. Hughes in his Presidential Address to the Society of Tel. Eng., Jan. 28th, 1886, and by Sir W. Thomson in his Presidential Address to the Institution of Elec. Eng., Jan 10th, 1889.

Prof. Hughes shows that a ribbon conductor is much superior to a cylindrical one for carrying currents of rapidly changing value, while Sir W. Thomson shows that the greater portion of such currents is carried on or near the surface of the conductors, and that a form having a large superficial area is best suited for these changing or alternating currents.

We are prepared to furnish concentric cables if desired though they are not much used in this country because the duplex cable offers practically the same electrical advantages and is easier to splice, branch off, etc.

In our cables, all conductors smaller than No. 8 B. and S. G, consist of a single solid wire, except in Multiple Cables, in which even so small a conductor as No. 8 B. and S. G. may be made up of fine strands for the sake of greater flexibility. When desired a number of electric light conductors can be bunched together and placed in one common sheath or lead cover (Fig. 6, page 27), and in this connection we commend particularly the Connor Cable (Fig. 7, page 27) to companies whose duct space is limited, or who are required to pay a high rental per duct, as by using this cable—say the four conductor—a great economy of space is secured and with vastly diminished danger of injury in placing the same, as compared with the same number of conductors in single wire cables.

Our Electric Light and Power Cables are extensively used by Street Railway Companies of Philadelphia, Boston, Rochester, Buffalo, Cleveland, Toledo, Chicago, and elsewhere, and by Electric Light Companies of the cities named, and of Washington, Baltimore, New York, Pittsburgh, Indianapolis, Milwaukee, Detroit, Minneapolis, and many other cities. In some of these the entire systems are of cables made and laid by us, and the aggregate of our cables of this class in successful use for various periods up to twelve years is several thousand miles, and at working pressures ranging from 50 to 7000 volts. The largest equipment of underground feeder cables for Electric Railway service ever installed was by us for a Company in Philadelphia, the work covering a period of three years and amounting to approximately one million dollars. The largest installation of underground cables for electric lighting is probably that of a Company in New York City, and the larger part of this was furnished by us beginning in 1888 and continuing yearly down to the present time.

In an article on "Wires and Cables" in the *Electrical World* of Nov. 28, 1896, the author, Mr. J. Draper Bishop, says:

"These considerations would seem to point to a combination cable, composed of a dry paper core with rubber compound sheathing, enclosed in the usual lead pipe. At first sight such a cable would seem to be one of perfect design, and nothing in past experience has appeared to justify the slightest doubt of its success."

This method of making cables (whether the core be "dry" or saturated) was patented by us on March 17, 1891, and prices will be quoted on application.

SUBMARINE CABLES.

(See Price List on page 32).

Where long lines of cable are to be laid under water, it is perhaps best to use conductors insulated with rubber, so that in case the protective covering should be broken or cut, the insulation of the wires will still exclude moisture for a considerable period of time. We are prepared to furnish Submarine Cables, containing conductors insulated with our high grade rubber compound, and well protected by heavy jute serving, (see fig. 28) and by a suitable size of galvanized iron wire; these will be furnished in any lengths desired. It is impossible to formulate definite price lists or discounts for such cables, but we will at any time, be pleased to furnish an estimate on receipt of specifications.

For all ordinary short lines see last paragraph page 32. For working directions see page 117.

LENGTH OF CABLES.

For convenience in transportation and laying, the length of cable should be as far as possible within the following approximate commercial lengths per reel, viz: 1 to 3 wires, No. 10 to 22 B. & S. G., 2,000 to 3,000 feet; No. 4 to 9, 1,500 feet; No. 4-0 to 8, 1,200 feet; larger sizes 600 to 1,000 feet; Anti-duction cables (page 28) 1,200 to 1,500 feet; Bunched cables 20 wires or less, 1,500 to 2,000 feet; 100 to 21 wires, 800 to 1,500 feet; over 100 wires, 600 to 800 feet.

It is, of course, possible to furnish these cables in any lengths desired, but it will be found more economical to make splices when the cables are being laid, and to increase the number of manholes in an underground conduit system, rather than increase the length of the cables; especially long lengths require the construction of specially large and strong reels at extra expense to the purchaser, and far more than proportionately increase the difficulty and expense.

DIAMETER OF CABLE.

Viewed from a mechanical standpoint a cable 2 to 2½ inches in diameter including the lead cover, is the largest that should be used, as the larger the cable the greater the danger of the lead cover buckling and breaking when bent. Anything larger would be so heavy as to greatly increase the difficulties of handling and drawing into the conduits. The diameter of the duct should exceed that of the cable by a full, clear half-inch and a margin of three-fourths to one inch is strongly advised.

FLEXIBILTY.

Our cables are all flexible, as we use only the purest soft copper and lead; they can, therefore, be easily and quickly handled, will pack in small compass and are not liable to injury from the settling of the earth due to frost or other causes.

The cables of the Standard Underground Cable Company are no longer in the experimental stage; they have been thoroughly tested under every possible condition, for upwards of 12 years and have, during that time, thoroughly demonstrated their efficiency.

To summarize:

WE CLAIM FOR OUR CABLES.

First—High Insulation with low specific inductive and electro-static capacity.

Second—Greatest possible freedom from induction.

Third—Greatest facility of branching and looping.

Fourth—Ease and rapidity of laying underground.

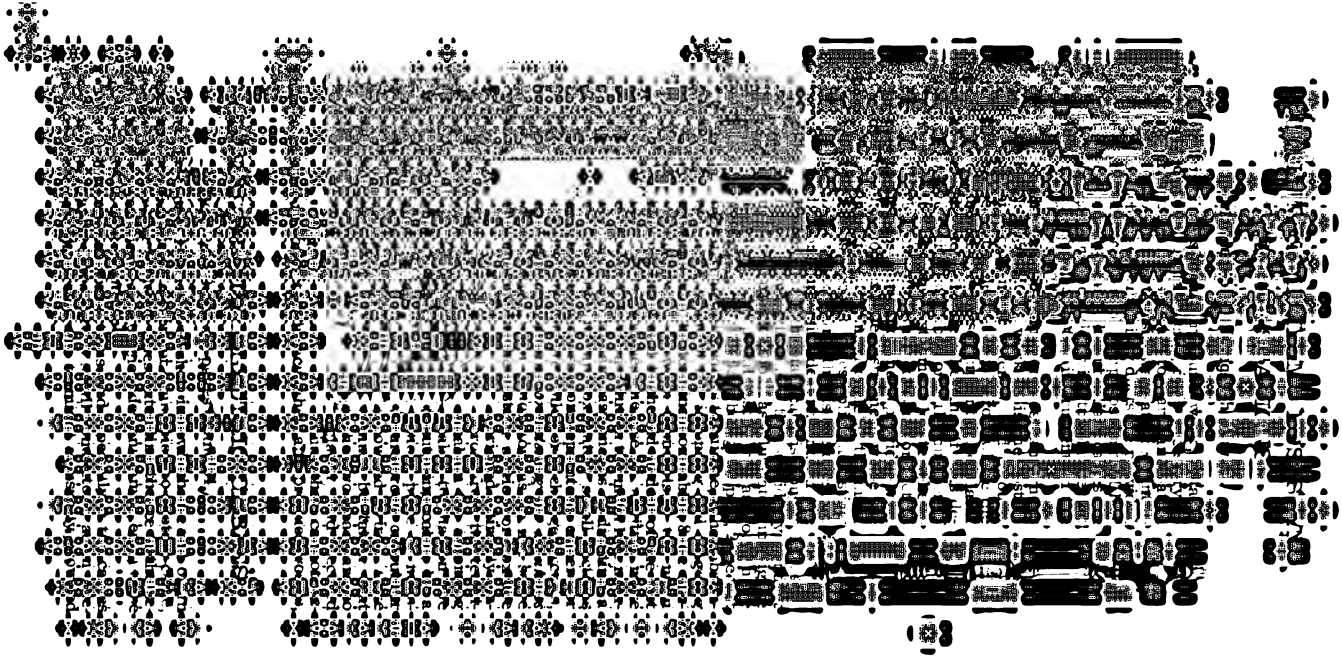
Fifth—Compactness and flexibility.

Sixth—Durability and freedom from interruption.

Seventh—The mechanical protection afforded by the lead cover.

Eighth—Perfect mechanical construction.

Ninth—**They have stood the test of time.**



with binding screws or posts, extending through its walls, to which the conductors of the cable are firmly secured in such a manner as to remain undisturbed when connections are made thence to other conductors. A convenient point of access is thus established for changing circuits or testing the separate parts thereof if faults appear, etc.

No matter how perfect an electric cable may be in construction or insulation, if its ends are not properly protected against moisture, its efficiency will soon be seriously impaired; therefore it is a common practice to place terminals on the ends of the cables. Where cable terminals are exposed to weather, as on poles or on houses or in damp basements, cellars or tunnels, they should be placed in a weather tight box as a still further protection against moisture and mechanical interruption. For inside work where there is little or no moisture present—as in dry cellars or basements—the box can be dispensed with and the terminals alone used.

Terminals have heretofore been in such form as to occupy large and sometimes valuable space, and have for the same reason, been quite expensive; they have consisted of an enlarged head, from five to ten times the cross-sectional area of the cable itself, with a contracted portion adapted to fit more or less closely around the cable, and generally connected to the cable by a wiped joint.

A much simpler, smaller and cheaper terminal has been devised by our engineers in the

TUBULAR TERMINALS FOR ELECTRIC CABLES,

(Patented December 29th, 1896.)

illustrated in these pages, and the fact that more than 2,000 of them have gone into use in the last four years for fire alarm, telegraph and telephone service, and from four to five hundred for electric light service, proves their value in the eyes of practical men

The object sought and attained is to provide a terminal whose internal cross-sectional dimensions and shape are the same as the corresponding external dimensions and shape of the cable to which it is to be applied, so that the terminal may closely hug the cable, thus making a tight joint between the two and occupying but little more space than the cable itself.

Referring to figures 27a and 27b, the shell or case 1 is made of sufficient length to provide a proper bearing upon the cable and sufficient space for the proper distribution of the conductors 2 to their binding posts 4.

For convenience in applying the terminal to telephone and telegraph cables and connecting the wires to the binding posts, the shell or case is divided longitudinally into two parts as shown.

If desired, the number of each wire may be stamped in the rubber under each binding post (for which an extra charge will be made), but the number of any wire or post may always be known by calling the first post of the left hand row "No. 1" and counting down each row in succession.

For a special application to Fire and Police telegraph system see opposite page.

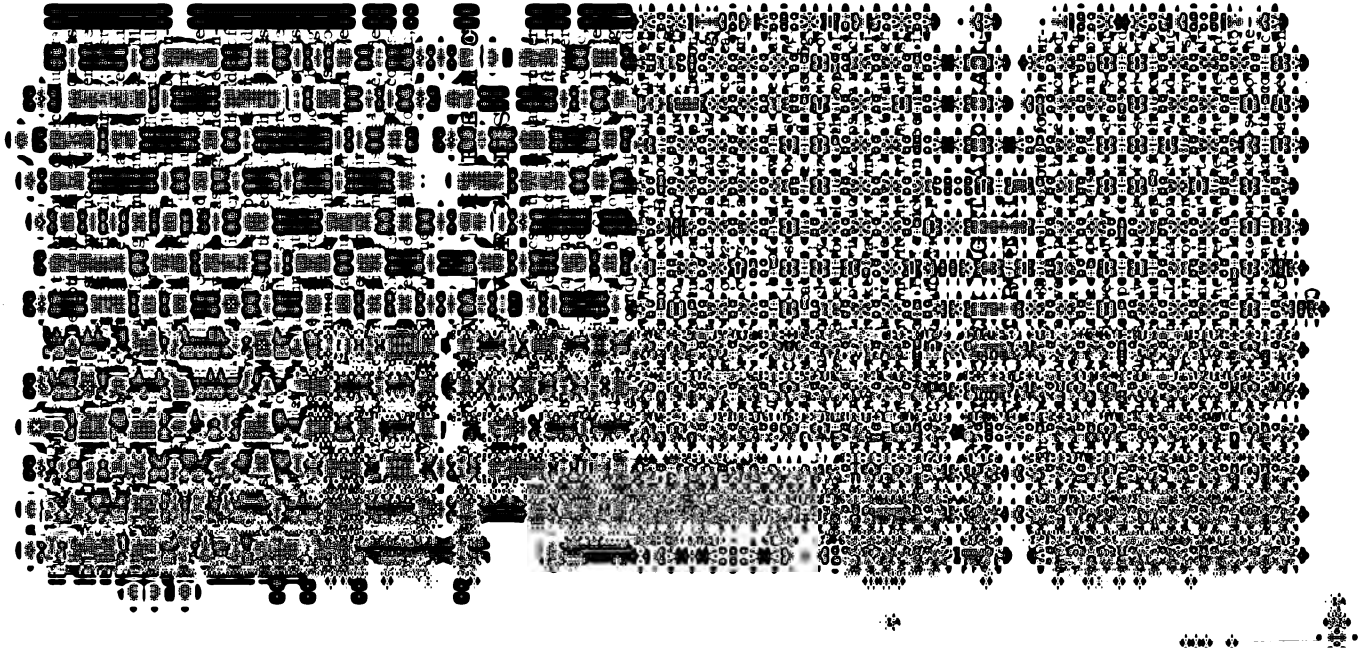
CAUTION.

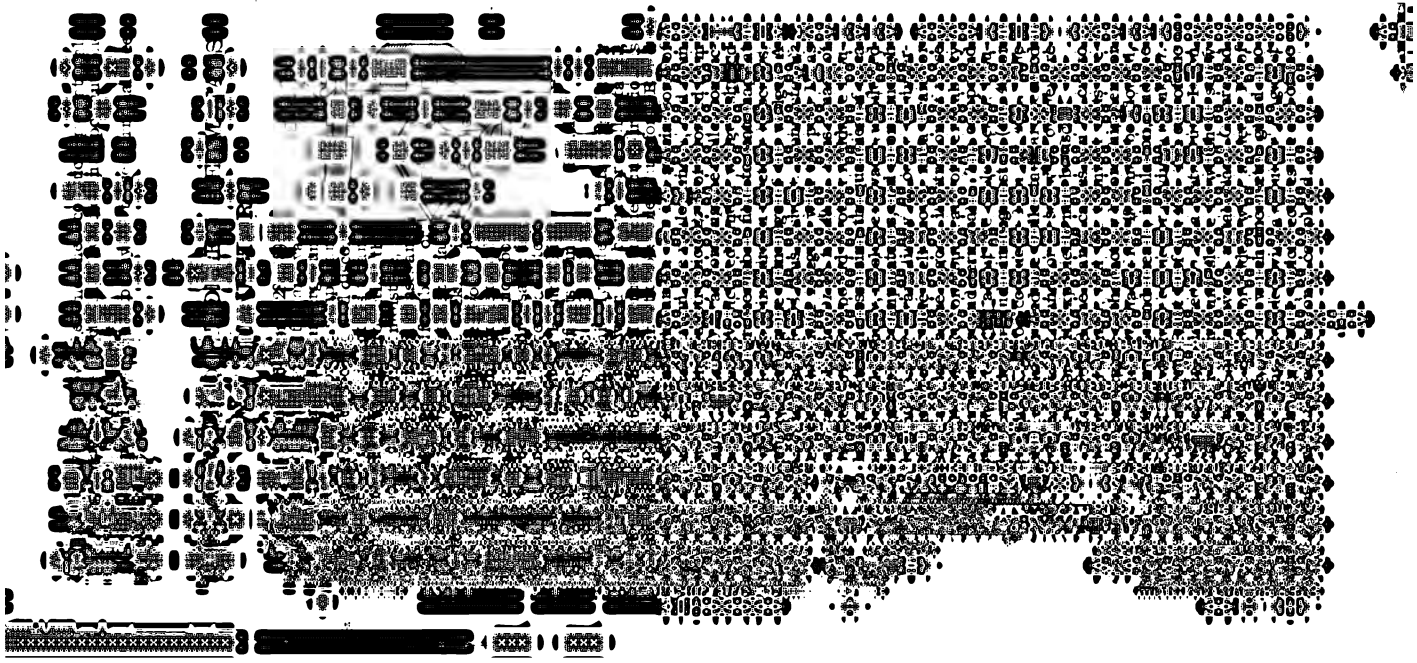
Any material may be broken if not handled with due care.

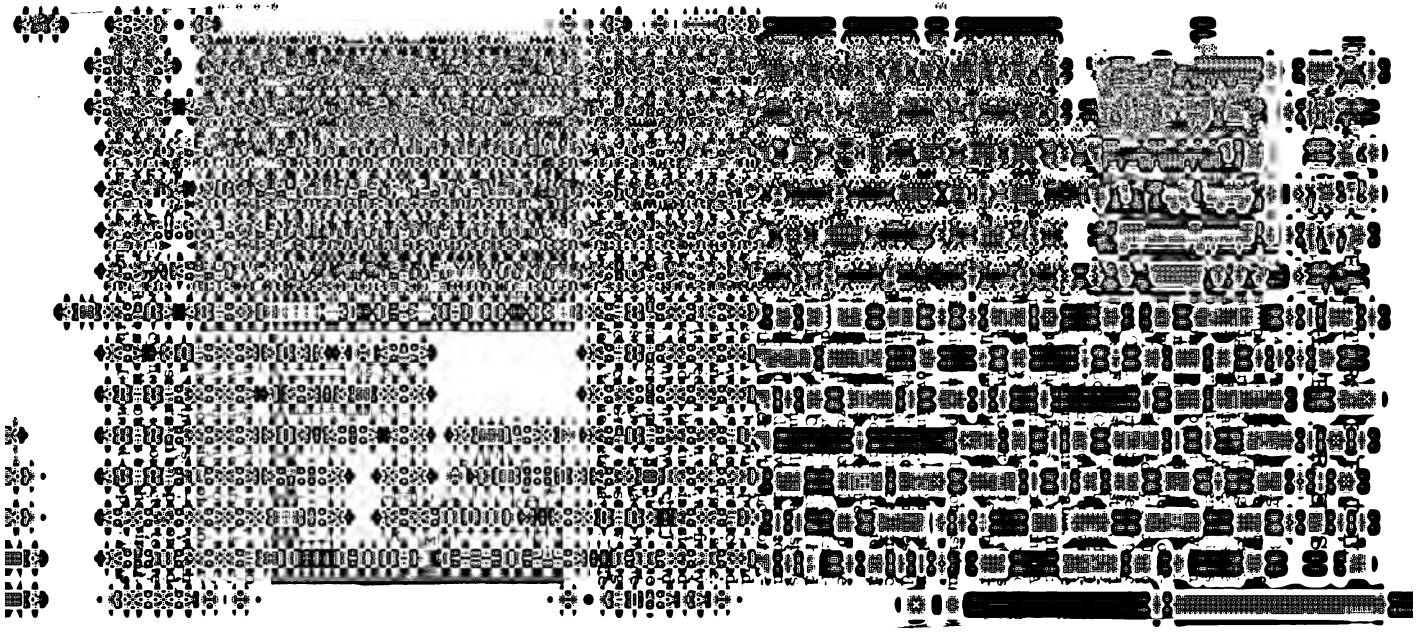
Do not screw up the binding posts so tight as to strip the threads or break the head. The screws are so proportioned as to give a tight and solid contact on the sizes of wire for which they are intended, and an over-exertion of strength is unnecessary and does not make better contact. In filling terminals be careful to have Ozite hot enough so as not to congeal before reaching the bottom, and not so hot as to melt the hard rubber.

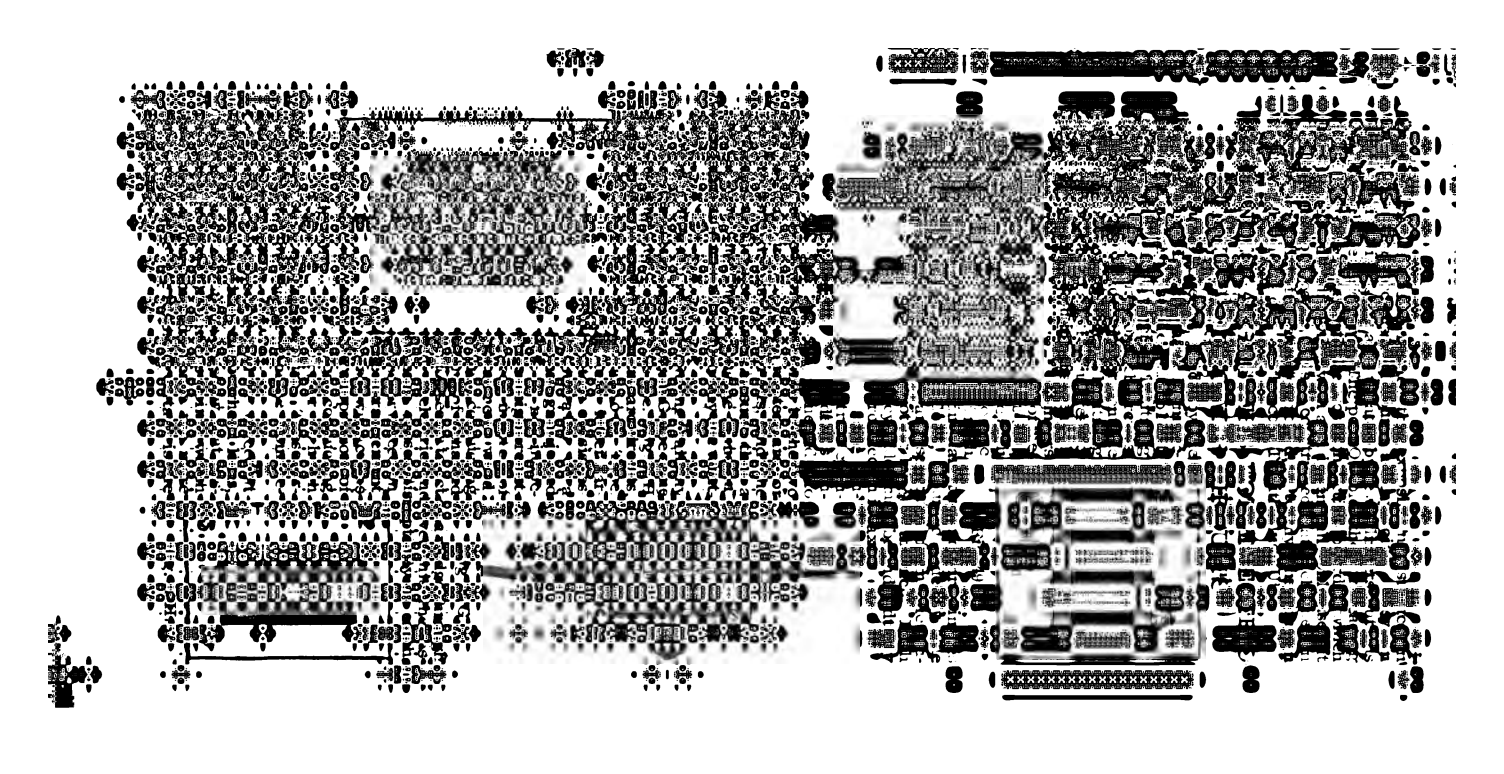
Screw the sides together tight to prevent Ozite from oozing out, and if necessary insert one or more layers of tape to act as a gasket. This latter precaution is unnecessary if terminals are ordered to fit the cables. If these precautions are observed, these terminals will be found absolutely satisfactory in every respect and present the special advantage of being smaller than any other terminal made.

Our **Degenhardt Hard Rubber Terminals,** (see page 34) consist of a hard wood top A, back B and front, the two sides D being usually constructed of hard rubber in which are mounted the binding posts C, by means of which a moisture-proof con-









AERIAL CABLE AND CABLE HANGERS.

(For Price List see page 85.)

Aerial cables are destined for a long time to be an important feature in the construction of telegraph and telephone lines in cities or parts of cities where overhead construction of some kind is still permitted.

Aerial cables represent a long advance over the ordinary overhead construction, for instead of, say, 50 to 100 single iron or copper wires attached to as many insulators on a large number of cross arms at each pole, all the wires are grouped together in a single cable one to two inches in diameter, neatly suspended at intervals of 24 to 36 inches to a slender but strong wire or steel cable which is firmly secured to the poles.

In street railway and electric light service, in many cases, instead of a large number of medium size feeders, say No. 0 to 0000 B. & S. G. attached to insulators at each pole, a few feeders of extra large size (we have furnished them as large as 850000 circular mils) can be substituted, thus obviating multiplicity of overhead wires and avoiding, to some extent, public criticism and objection. These large feeders, owing to their great weight, are usually supported in the same way as are telephone and telegraph cables.

The little device by which cables are attached to suspending wires as in the cases above mentioned, is known as

A CABLE HANGER

and the cable hanger which can be most readily attached to and detached from the cables and the suspending wire *at will*, and which is not easily detached from either *by accident*, must commend itself to the favor of thoughtful, practical men, if at the same time it offers no injury to the cable, can be removed without injury to itself, and is no more expensive than other hangers.

A cable hanger which meets all the essential requirements, and which has been in general and extended use in vast quantities since we first put it on the market in 1890, is the invention of Wm. A. Conner, General Superintendent of our Manufacturing Department, and is known as our

ONE PIECE MALLEABLE IRON CABLE HANGER.

Patented February 4, 1890.

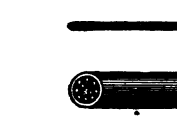


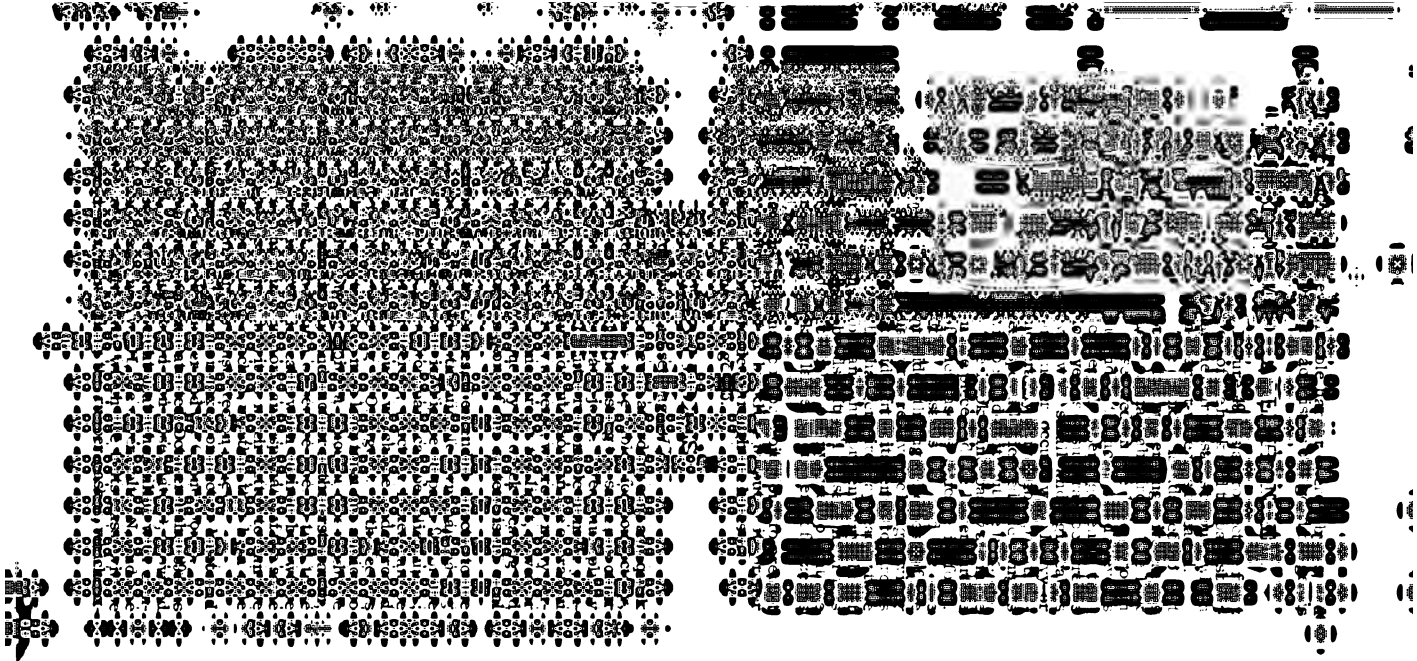
Fig. 49 I.

This is the simplest hanger on the market today, being complete in one piece It is made of the best malleable iron so as to give the greatest ductility consistent with sufficient strength to support the cables without opening by their weights. They are easily and quickly applied or removed by the special tongs furnished by us. The inner edges of the broad band 3 (see fig. 49 I) are beveled so as to avoid all danger of cutting the cable, which is gripped so firmly that it cannot turn or chafe in the hanger, all movement taking place between the round hook 1 and the suspension wire 2. In ordering give diameter of the cable to which the hanger is to be applied.

These cable hangers are also well adapted for supporting cables around the sides of manholes, in which case staples, driven into the wall at suitable intervals, are substituted in lieu of line wire.

Where an extra good piece of construction is desired and the slight additional expense is no object, we advise placing a piece of sheet lead, say $\frac{1}{8}$ inch thick, or a piece of leather or rubber hose, around the cable at the point where the hanger is to be applied; but if this is to be done, the additional thickness must be allowed for in ordering the hangers. In ordering refer to stock numbers in price list to designate size desired; each hanger bears its stock number.

For working directions see page 135.



tends entirely around between the flange of the cover and the base plate, in making a thoroughly water-tight structure. The cover is provided with handles, and the base plate rests upon two brackets secured to the sides of the manhole. To guard against accident to the employees in lifting off the cover of a "live" box, the cover is lined with ½-inch wood L, which is thoroughly dried out and saturated with our Ozite insulating compound. The iron parts are painted to prevent rusting. The illustration shows a square box (either two, three or four way) but it can be extended in rectangular form to take in any reasonable number of cables. The base plate is provided with downwardly projecting nipples to receive the cables E, and a water-tight connection is made by first tinning both the cables and the inside of the nipple, and then pouring in solder at the enlarged inner end, O, of the nipple. A, is the straight main connector, B the curved branch connector, C the cable conductor, D the insulation, R a thumb nut, S a set nut, T a binding post, P the hard rubber terminal with cap, and I the filling of compound. These details are shown more clearly in fig. 48. Five hundred to six hundred of these junction boxes are in successful use by one street railway company alone.

The advantages of this box are that it is roomy, that when the cover H is lifted off, all the connections extend above the flat base plate, and are, therefore readily accessible, and that it can be made any desired length permitted by the size of the manhole, to take in a large number of cables. Prices of these boxes to take in more than four cables will be quoted on application. In ordering state the number of cables, and the diameter of both the conductor and the cable, and whether main or branch connectors are desired, so that the proper fittings may be included in the shipment

The Conner Junction Box. (Patent applied for.) Illustrated in fig. 88, is the most simple and compact device yet produced. It is, in fact, a combined joint and junction box, being but little larger than a regular sleeve joint, yet affording easy access to the separable connectors inside of the lead sleeves. It is supported by pipe hangers against the side of the manhole in the position shown in fig. 49 J', and encroaches but little more than the cables themselves, upon the manhole space. The two-way box (whether for single or duplex cable) would have only the right and left arms, a three-way box, these and the lower arm, and a four-way box all the arms or ways shown in the illustrations. If the box has more ways than are at first needed, the extra ways can be securely soldered up, and then opened to receive additional cables when necessary. In fig. 88, A is the main connector, B the branch connector, C the conductor, D the insulation, and E the lead cable sheath; F is a regular wiped joint, such as would be used in making the regular solid Sleeve cable joint.

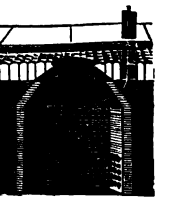


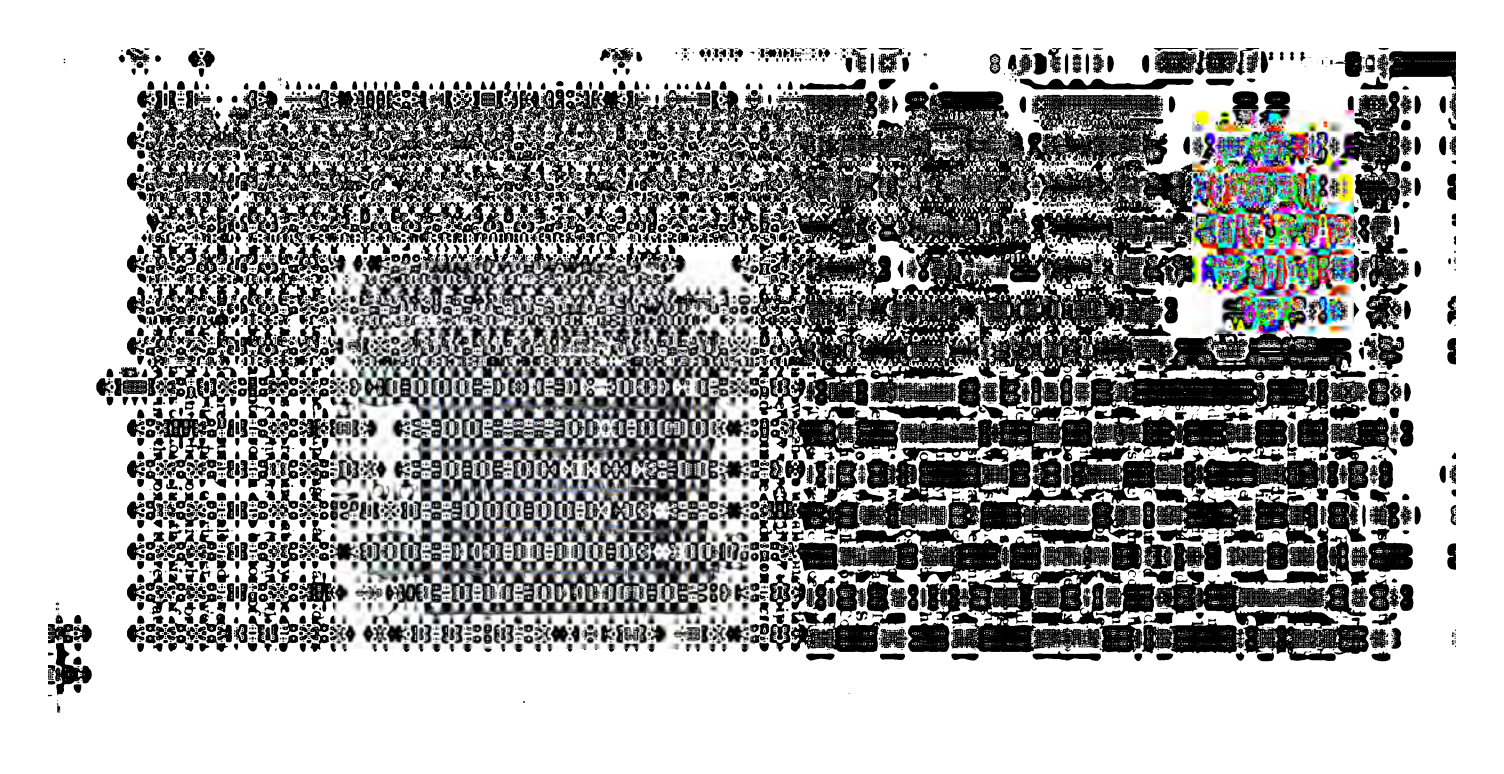
Fig. 49 J'.

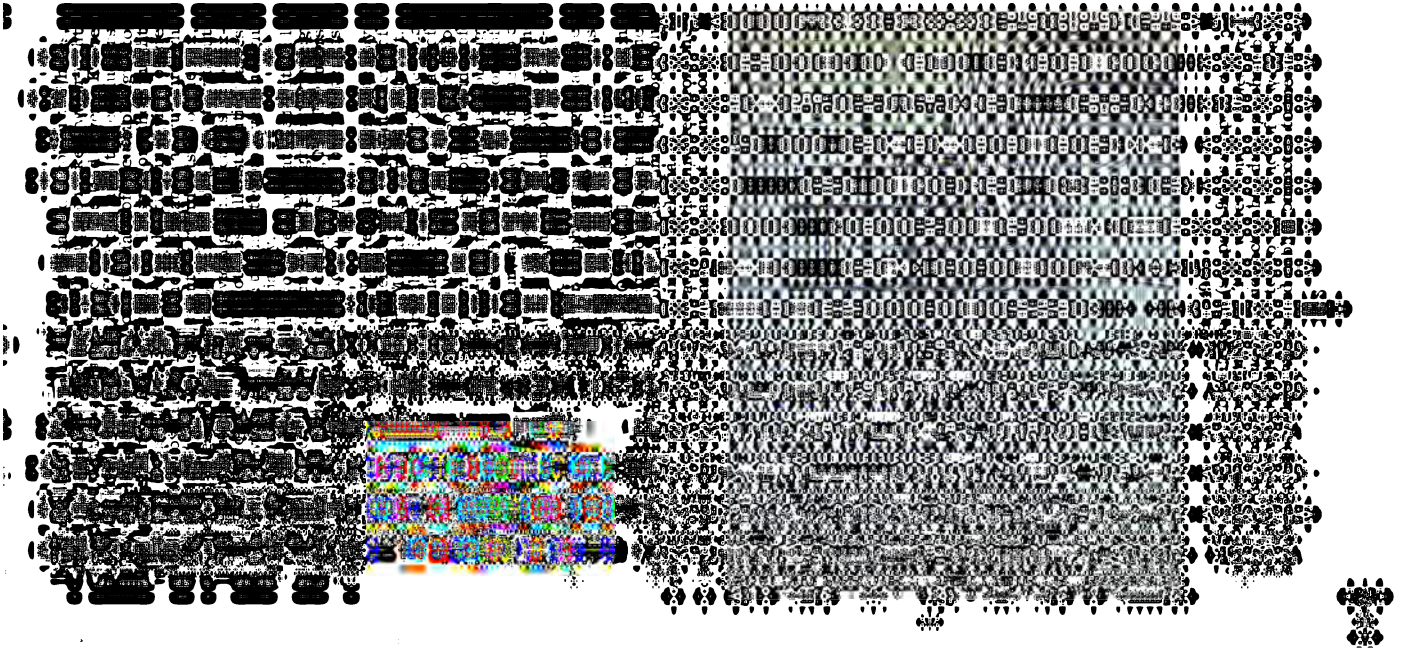
A brass top is soldered to the lead case, and upon this is placed a rubber gasket having holes, to correspond with the holes in the brass top, to receive the bolts N which pass through the brass cover H. The cover being comparatively small, it is pressed uniformly upon the gasket with great force, and without any danger of springing. W is a wrench used to release or set the connector screws all of which are made alike. The figure also shows the details of the conductor connections within the box—for single wire branch box at the upper left hand corner, and for a duplex branch box in the right hand upper corner Also, in each case, the post or head J soldered to the cable conductor.

The connections are carefully taped, or a pure gum sheet is tucked in between them to prevent all danger of short circuits. The box and cover are carefully lined with heavy rubber faced tape to prevent accidental "grounding."

JUNCTION BOXES FOR TELEPHONE AND TELEGRAPH CABLES.

While strongly advising against the use of many junction boxes for such cables, because of their great bulk where many wires are to be made properly accessible (as in fig. 49M) and also because of the much more safe, convenient and adequate plan





branch, leads up to the switchboard on the floor above, being supported on standards fastened to the walls. In the middle of the rack are seen two of our telephone boxes (page 97) by means of which telephone connection can be readily secured with any desired point on the system for test purposes.

UNDERGROUND CONDUITS.

(See Price List page 86.)

The disastrous storms of the past few years and the havoc among overhead wires caused thereby, has greatly increased the demand for underground cable construction, both as adding to the safety and convenience of the people, and to the sightliness of the streets.

Until very recently it has been felt that only the largest cities could afford to place the wires underground, but careful consideration and investigation have proved that the advantage gained from the decidedly decreased cost of maintenance of underground lines as compared with overhead wires, not to mention the increased safety of the streets, justifies the expenditure of large amounts of money for underground systems, as a good financial investment, and indeed that where a very large number of wires is to be provided for, the first cost is less underground than overhead. (See page 180.)

The smaller cities and towns are now consequently calling for underground construction at least within the more closely built up business portions of the municipality.

A system of underground distribution in order to give complete satisfaction, should be so flexible as to meet all demands made upon it with the minimum of delay and expense.

The early experiments in subway construction contemplated only the placing of the wires out of sight, and took no thought for renewals, changes or additions, which are required in any system.

The wires were therefore placed in rough wooden boxes 18 inches to two feet below the surface of the ground and usually entirely surrounded by some insulating material, such as pitch. This made a very cheap system, but one that was incapable of changes or additions, without great expense. It was soon proved that such a system could not give permanent satisfaction for purposes of general distribution, and it is only used to-day under special circumstances, and has been succeeded by conduits which permit of drawing wires or cables in and out at will.

The conditions existing in any locality, must necessarily govern the selection of the conduit to be used there, and it is safe to say that no one system is most suitable for all conditions and locations. It is now well recognized that it is practically impossible to maintain any underground conduit dry or gas tight, hence it is not depended upon for insulation but only for mechanical protection. There are however, conduits, and conduits, and good, bad, and indifferent ways of installing them. We shall try to indicate the best conduits and methods.

Lap welded wrought iron pipe, laid in cement, would seem from a superficial view to meet all the requirements of a flexible and adaptable subway system, but the following objections to its use in addition to the objection of very high cost, are worthy of careful consideration.

First.—One of the most serious, electrically, is the increased self induction of the circuit and the consequent loss of electrical energy when alternating currents are used. The great increase in the use of polyphase apparatus makes this a very serious defect. (See Self Induction page 85.)

Second.—One of the most serious, mechanically, is corrosion and formation of scale which in time blocks the duct and prevents the withdrawal of the cables, or placing of new cables in a duct without reaming it out where the duct has not been used for some time.

Third.—The joints between sections of pipe almost invariably present sharp edges, which are liable to injure and even ruin the cable as it is being drawn in.

Fourth.—Iron pipes are usually coated both inside and out, or else the joints are made more secure, with tar or pitch; in warm weather, or at any time when laid adjacent to steam heating pipes, this tar or compound softens and gathers in the bottom of the pipe and around the cable, so that when it is attempted to withdraw the cables from these pipes, as may some time become necessary, it is impossible to do so without greatly injuring or totally destroying them.

Fifth.—Where a section of the iron pipe ends in a manhole or junction box, the sharp edge of the pipe gradually cuts through the outside cover, to the great injury of the cable.

Conduits constructed wholly of **compounds of tar or pitch** and sand, etc., are open to the objection noted above against iron pipe, except that the dangers are greatly increased; such conduits are also objectionable because of the difficulty of preserving the alignment between the various sections.

The chief use now made of iron pipe, is for the branch conduits to and up poles and buildings and this is the only purpose for which they are peculiarly well adapted. The conduits illustrated on page 36, which we shall now describe in order, have been chosen out of the many conduits now in the market as possessing the qualities of permanence and moderate cost, and avoiding all of the objections above mentioned. We are prepared to furnish any of these in any quantity, and we are peculiarly well able, from long experience in underground installation, to advise impartially and intelligently as to the most advantageous conduit to use, under the conditions with which a purchaser may be confronted Three inches internal diameter is the size commonly used, but whatever size is chosen, it should represent a margin of at least ½ an inch over the diameter of the cable, and ¾ to 1 inch is preferable.

CEMENT LINED IRON PIPE.

This conduit (see figs. 29 and 30), consists of a wrought iron or steel shell, No. 26 B. W. Gauge securely fastened by rivets 1½ inches apart, and lined with ⅝ inch best Rosendale Cement. By a special process the interior surface of the cement is highly polished, thus removing all roughness, which in the conduit of this character heretofore placed on the market, has been the source of considerable trouble by scratching the lead cover of the wires and rendering it difficult to draw in heavy cables.

It is made in lengths of eight feet and with interior diameters of 2 inches, 2½ inches and 3 inches; the latter being the standard size. Each length is provided with cast-iron ball and socket ends which give certainty of alignment and perfect joint. The joint as completed is clearly shown in fig. 30, surrounded by a mold of neat cement mortar, which sets very quickly, and secures the pipes in place until the matrix of concrete is put in place. A cross section of a conduit, consisting of twelve of these ducts surrounded by concrete matrix, is clearly shown in fig. 29. For detailed method of laying these ducts see page 112.

HOLLOW BRICK TILE CONDUIT.

The hollow brick tile conduit, fig. 31, commonly called "Terra Cotta" or "Vitrified Brick," is made from the best clay thoroughly mixed, molded into shape and carefully burned with a salt glaze. This treatment renders the clay impervious to moisture and presents a very smooth surface which admits of drawing in the largest cables with great ease. The ducts are made in lengths of 18 inches and with an internal diameter of full 2 inches, 2½ inches and 3 inches, the latter size being most generally used. The ends are cut square and fit closely together. They should be protected all around by a bed of concrete, to prevent breaking of the joints and of the ducts themselves. Large quantities of this duct, have been laid in Philadelphia, Washington, Norfolk, Buffalo and Cincinnati, and particularly by the telephone companies. For details of installation see page 112.

MULTIPLE CONDUITS.

Fig. 49 P.

The tile conduit can also be supplied in multiple style, 2 to 12 chambers, (see fig. 49P) and 6 to 8 feet long, and possessing extraordinary strength. It effects a great economy in freight, handling, cement, width of trench, and paving.

WOODEN CONDUITS.

Wood conduit, otherwise known as "Pump Log," has been used in large quantities and for many years in this country. The form of duct is shown in fig. 32. The tubes are eight feet

Many companies prefer double covers (see fig. 50) the lower resting on a rubber gasket and provided with a device for securing it firmly on the gasket, to prevent the entrance of surface water. In some cases this is a decided disadvantage, for any arrangement which excludes water will usually retain gas which may leak in, especially in large cities where the gas mains are in bad condition; and this sometimes results in disastrous explosions. The best practice is to have a perforated single cover to supply ventilation, and allow the sewer connection to take care of surplus water. It is a good plan to lock the covers, so that no unauthorized person can get at the cables without breaking the lock.

HAND HOLES OR FLUSH BOXES.

(For Illustrations see Figs. 51 and 51 A.)

In some branches of underground construction it is necessary to provide more frequent openings to the cables, for the purpose of distribution to houses, stores, etc., than is afforded by the main manholes. For this purpose small brick manholes, or rectangular cast-iron boxes, (see fig. 51), usually termed "Hand Holes" or "Flush Boxes" are placed as desired, flush with the surface of the street, and intersecting those ducts of

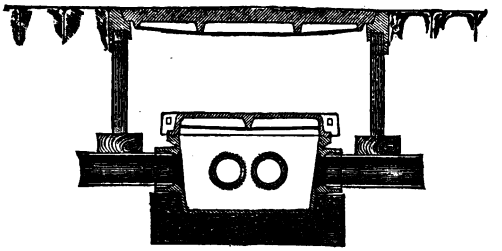


Fig. 51.

the conduit which carry the distributing cables, the top layer of ducts being used for this purpose, (see plan, fig. 51 A). These ducts are placed as near the surface as possible and the hand holes are built where necessary. They are provided with a cover as manholes are, and if cast-iron boxes are used, they have the necessary outlets cast on them to receive main and subsidiary pipes. No handhole is adapted for all purposes, but we are prepared to submit plans for any system which will best suit the

Fig. 51 A.

demands of the case. A "Service Box" is a type used in New York for lighting distribution and is of cast-iron about 2 feet long, 1½ feet wide, and 2 feet deep, provided with double covers the lower of which rests on a rubber gasket and all covered over by the paving. Spigots or outlets are provided at the sides through which cables are carried to adjoining basements, where service connections may be desired, the distributing cables being tapped for that purpose.

MISCELLANEOUS TOOLS AND DEVICES.

(For Price List see page 38).

In laying, splicing and connecting cables certain tools and accessories are necessary or useful, and these we now describe.

Tubular Braid. This as its name indicates, is a braid of fibrous material woven in shape of a tube, so that it can be drawn over the splice after two wires have been connected; it serves to insulate the wire splices from each other or from the metal covering of the cable joint. In ordering state size of conductor on which it is to be used. See page 127.

any intelligent man can make perfect joints, and in the regular work of construction the use of these molds by expert jointers will greatly increase the number of joints made per day.

Complete-Joint Molds or Sleeve-Joint Molds will be furnished if desired, for use on Duplex Cables, but in ordering these full information should accompany the order, and whenever possible a short sample of the cable for which the mold is wanted.

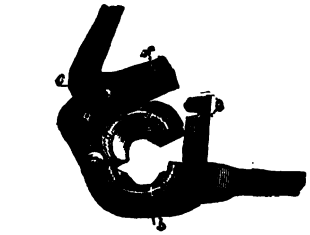


Fig. 54.
Sleeve-Joint Mould.

Sleeve-Joint Mould. The general remarks under "Complete-Joint Mould" apply also to this tool. This device is used—not for making a complete joint—but for making a solder-wiped joint to connect the lead cover of the cable to the lead sleeve which has been drawn over the insulated wire splice. See page 126 and balance of this page.

It is shown in Fig. 54. *a* is the space in which the melted solder forms and unites with the sleeve and cable; *b* is one of the removable parts of the mould to enable it to be used on a cable of any size within certain limits; it fits closely upon the cable and lead sleeve; the removable parts are held in place by small hooks; *c* is the cam lever which is raised when the mould is to be opened and which, when lowered, serves to clamp the mould tightly upon the lead cover of the cable and upon the sleeve to prevent any flow of solder outwardly from the mould or inwardly to the conductor; the pin *d*, limits the movement of the cam lever; *e* is the latch and *f* is the engaging bolt or pin to lock the two parts of the mould firmly together.

Lead Sleeves or Tubes. In making joints on certain kinds of cable (see "Jointing") and in connection with the Sleeve-Joint Mould above described, it is necessary to use lead sleeves or tubes, and we are sometimes requested to furnish them.

In sending an order for these, state the diameter of the cable on which they are to be used and the number and size of the conductors. As a rule the inside diameter of the sleeve should exceed the outside diameter of the cable by $\frac{1}{2}''$, the ends being dressed down in a short curve to fit snugly upon the lead cover of the cable; it should be of such length that when centered over the taped wire-splice or splices, each end will overlap the lead cover of the cable at least $\frac{1}{2}''$. If the sleeve is used for a joint which is to be drawn into a duct, its interior diameter should not exceed the exterior diameter of the cable; if it is used for a joint in which the wire splices, even when distributed over the longest practicable range, form a bunch thicker than the diameter of the cable, the size of the sleeve must be increased in proportion. The lead should be of at least the same thickness as the lead cover of the cable itself.

In preparing the sleeve, care should be taken that it is large enough to admit the free flow of the melted insulation on all sides of the insulated wire splice, when the joint is filled. Before slipping the sleeve onto the cable, the hole or holes should be tapped in it for the hot insulation and overflow described on page 127, and the ends should be well reamed out so as to facilitate dressing them down snugly to the cable.

Lead Tees for Branch Joints. (See Fig. 80, page 129.) These are used for making half connections or branch joints from a main cable to a way-station or a service line. As to size, etc., see "Lead Sleeves" above.

In ordering these, state the diameter of the main and branch cables and the number and size of the conductors in each.

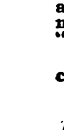


Fig. 54 A.

Rotary Wire-Splicing Tool. The old method of making wire splices is slow, and when the conductors are small in size there is great danger of twisting them so hard that they will break or become so weakened that a subsequent movement of the cable-joint severs them, thus making "open" wires, and frequently causing heavy expense and loss of service.

size; *k* is a movable portion of one jaw and has imparted to it an upward and downward movement by means of the eccentric or cam attached to the pinion *k* by the key *l*; when the handles of the tool are brought towards each other, it moves downward and causes the anvil *b* to press upon the copper sleeve and its contained wires with immense pressure.

For Working Directions and Illustrations of the Copper Sleeve and Joint, see pages 125 and 126.

Copper Sleeves for Wire-Splicing Tongs. In connection with the tongs just described, it is necessary to have copper sleeves or blanks of such size and shape as to be suited to the size conductor that is to be spliced, and to the corresponding removable anvils of the tool.

In ordering these blanks, please state the size of conductor on which they are to be used.

The weights, etc., are given in detail as follows:

Size of Wire. B. & S. G.	Thickness. (Inches.)	Length. (Inches.)	Width Before Being Bent. (Inches.)	Approximate Number per Pound.
10	1-32	3/4	.6217	213
12	1-32	3/4	.5133	258
	1-64	3/4	.4643	572
14	1-64	3/4	.3779	708
16	1-64	3/4	.3102	857
18	1-64	3/4	.2564	1038
20	1-64	3/4	.2134	1245

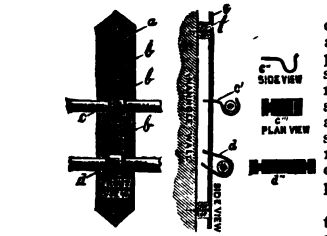


Fig. 60.

Cable Supports. In passing cables through a manhole from a duct on one side to the corresponding duct on the opposite side, it is important, for obvious reasons, to lay them around the sides, instead of straight through, and in order that they may not sag towards the bottom of the manhole or be cut on the edges of the duct these supports are provided.

In fig. 60 are shown views of this device in detail and as applied; *a* is a post or standard secured to the sides of the manhole or tunnel in any suitable manner, and provided with vertical slots *b*, cleats or blocks *f* being interposed between the standard and wall; so as to give a slight clear space for the attachment of the hanger or supports, *c*, *d*, *c'*, and *d'*; two forms of the hanger are shown in detail at *c''*, *c'''* and *d''*. It is made preferably of resilient material, and of such size as to take a firm grasp on the cable. For Working Directions see page 117.

Our regular malleable iron cable hangers (see pages 35 and 94) are however simpler and cheaper and are extensively used for this purpose. A staple (fig. 60) is driven into the wooden post, the hanger is clamped to the cable and hooked into the staple. In either case the edges of the hangers are flared to prevent injury to cable.

In ordering hangers of either kind be careful to state the diameter of cable for which they are intended.

Insulating Tape. This is supplied in white or black, any desired width, but ½ inch and ¾ inch are the common sizes. The cloth is finely woven and is frictioned with rubber compound on one side only unless otherwise ordered. It is used for taping splices on house and line wire, etc.

Pure Gum Tape will also be supplied (prices on application) for taping the wire splices on our rubber insulated cables.

ELECTROLYSIS.

This is a danger against which no manufacturer can protect or guarantee the buyer, so far as the manufacture of the cable is concerned, since it is a matter entirely apart from the quality of the cable or the current for which it is made, but is a matter which the buyer can avoid or remedy by well-known means. To this end we give our customers in the following report the benefit of our investigations, and urge the adoption of the proper means for preventing the destruction of their property, if it is taking place. The report was written by Mr. Fisher just before Mr. Farnham's interesting and valuable paper on the same subject was read before the American Institute of Electrical Engineers:

PITTSBURG, PA., April 10th, 1894.

STANDARD UNDERGROUND CABLE COMPANY, MR. J. W. MARSH, V. P. AND G. M., PITTSBURG, PA.

Dear Sir:—This report has been prepared with a view to enabling our patrons to take such precautionary measures as will prevent their cables being destroyed by electrolytic action from the ground return current of electric railroads.

While the destructive effects of such currents upon water and gas pipes and lead-covered cables have for the most part been known for several years in a few of the larger cities of the United States, yet in very many places such electrolytic action has not been suspected until the cables were found to be very materially damaged by it.

The amount of electrolytic action depends primarily upon:

(*a*) The proximity of the cables to the electric railroads.

(*b*) The distance the cables parallel the electric railroads.

(*c*) The quality of the electric railroad construction work providing a path for the ground return current.

(*d*) Numerous other things, comprising the polarity of the ground return current, the conductivity of the soil, and the position of low soil resistances along the route of the cables, the proximity to the cables of water and gas pipes, and the chemical constituents of the earth.

For several months past I have been carrying on experiments in the laboratories of the STANDARD UNDERGROUND CABLE COMPANY, relative to the effects of electrolysis upon lead cables, with a view to determining by what means it can be prevented or counteracted.

Nothing very new is claimed from the results of these experiments, seeing that they are confirmed by theory and current literature upon the subject. However it is hoped that the suggestions which arise as a natural consequence of these and other experiments may prove of benefit to at least some of our patrons in preserving their cables from electrolytic action.

It is a well-known fact that when a current of electricity passes through water or a moist medium the water is in part decomposed, oxygen being liberated at the positive pole and hydrogen at the negative pole. Oxygen in its nascent or free condition attacks most metals readily, forming oxides of the metals. It is therefore at the positive pole, or where the electric current leaves the metal, that we must ordinarily look for its injurious electrolytic effects.

I commenced my experiments upon four samples of lead-covered cables.

The lead of Sample No. 1 was pure and was directly exposed to the electrolytic action at a few places; part of the remainder of the cable was covered with a heavy tape, saturated with a preservative paint, and the rest was covered thickly with half-and-half solder.

Sample No. 2 was like the above, with the exception that the lead cover consisted of an alloy of three per cent. tin and ninety-seven per cent. lead.

Sample No. 3 was like No. 1, and Sample No. 4 like No. 2.

Samples Nos. 1 and 2 were subjected to a direct current, and Samples Nos. 3 and 4 to a direct current whose polarity was reversed daily.

These samples were laid in the centre of a long box, and moist earth from the street was placed around and over the samples. At the side of each box was placed a strip or rod of iron one-quarter of an inch thick by one inch wide. One terminal of a one-hundred-and-ten-volt dynamo was connected to the iron strip, the other to the lead cable.

The tests on Samples Nos. 1 and 2 were commenced with the positive pole to the iron rods, and this connection was maintained for about twenty days, when a preliminary examination showed that the lead was not at all corroded, while the iron rod was oxidized to such an extent that it had to be replaced by a new one. At this juncture the polarity of the dynamo was reversed, the positive pole being connected to the lead, and the tests were continued for about fifty days longer. A little before the expiration of this time the insulation resistance of Sample No. 1 became low, indicating that some portion of the lead cover had been destroyed.

During these tests water had to be added from time to time, in order to regulate and equalize, as far as possible, the amount of current flowing to each sample.

The maximum current to each sample was seldom over one-half an ampere, and was generally quite a little less. The samples were then removed from the boxes, and a careful examination of each showed as follows:

The lead of Sample No. 1 was eaten completely through in several places. One of these was under the tape cover, another where the lead was exposed. The portion covered with solder had also been completely attacked. There were signs of electrolytic action practically all over this piece of cable, the portion least attacked being under the preservative tape.

The action upon Sample No. 2 was quite as apparent as on Sample No. 1. Whether it was as intense as on Sample No. 1 I could not say owing to the fact that No. 2 was a much larger cable, and hence the oxidization was more distributed.

Samples Nos. 3 and 4 were both oxidized, but owing to the daily reversal of the current the action was not nearly so great as on Nos. 1 and 2.

Subsequent to these tests I have made others which fully confirmed the above. One of these was made to conform more closely to the condition of things in practice. I have simply mentioned these tests briefly in order to lead up to the more important part, viz.: the conclusions and recommendations that follow as a natural consequence.

In the first place it is evident that a cable covered with an alloy of tin and lead is in no wise proof against electrolytic action. I have on several occasions heard people claim the reverse of this statement. It is also evident that while preservative tape may lessen the amount of electrolysis, yet it is by no means reliable as a sure preventive. That is, however, no indication that the tape would not be an efficient protection against chemical actions, unaccompanied by electrolysis.

Reversing daily the polarity of the electric railroad generators will prolong the life of the cables, but will not prevent their ultimate destruction.

Coming now to the final and most important consideration of this matter, the tests show that if the current can be made to pass from earth to the cable and not back to earth again FROM it, we are insured against electrolysis of the cable.

It is therefore evident that the best conditions are reached when the negative sides of the electric railroad dynamos are grounded, and the lead of the cables is connected solidly by means of a heavy copper conductor to the negative sides of the dynamos. The lead cover under these conditions conducts the currents that reach it from the earth directly back to the dynamo.

If there are more cables than one, it is advisable to connect them all together at frequent intervals, so as to make the resistance as low as possible, as well as to prevent currents passing from one cable to another by other than a metallic connection. The lead covers of all the cables should, of course, be connected to the negative buss bar.

When the above plan is not feasible, the life of the cables might be prolonged at the expense of a very large ground plate, which should be connected by heavy feeders in the cables and inserted in a point along the route of the cable where the soil is most moist, preferably near the power-house, or at all events nearest the probable path of lowest resistance to the power-house.

To illustrate: The power-house might be situated by a river, in which case, if the cable at some point reached the river, it might be advisable to place the ground plate there, even though the cable was nearer to the power-house at some other points. However, no set rule can be given for this case. The electrician in charge should use his own judgment as to the application to his particular case of the suggestions here given. If this plan is adopted the ground plates should be of copper, and they should be examined frequently until the apparent rate of disintegration would enable one to determine the probable life of the plate. I simply suggest this as a plan that might be used under very favorable conditions of low soil resistance; however, as ground plates often prove inadequate for heavy currents, they are falling into disrepute, and hence the copper returns from the

cables to the dynamo is the only really safe plan. Care must be taken to see that the negative side of the dynamo is grounded.

In some of the large cities the electric railroad companies have been obliged to use underground feeders for carrying their currents to the points of distribution, and in order to protect these cables against electrolytic action, as well as to furnish a low resistance wire-return, they have supplemented the ordinary track feeder, or ground wire, with additional heavy return feeders, which are laid in ducts near the cable and are connected at every manhole to the track. To still further insure the life of the cables we have recommended connecting the lead covers to these return feeders at frequent intervals, also at the power-house, to the negative buss bar. In practice we make the connection from the lead cables to the return feeder and the negative buss bar by means of a suitable number of tinned No. 10 wires. All the joints are carefully soldered. When there are only a few cables and the distance is short we commence with one wire and note its temperature. If the heating effect is considerable we connect enough wires to carry the current without damage by heating. I simply recommend No. 10 on account of its flexibility and the consequent ease with which it can be wrapped around the cables and return feeder. When the above plan is adopted I do not recommend specially grounding the negative side of the dynamos at the power-house, because the more thoroughly this is done the more opportunity will be given for the current to leave the cable along its route and return to the dynamo via the ground. I think the better plan would be to increase the carrying capacity of the return feeders for a distance of several hundred feet from the power-house. The economy to the railroad company of such a plan, in saving the expenditure of unnecessary energy in resistance-loss, is at once evident, and it is thought that in many cases the electric railroad companies will be willing to co-operate with the other companies by laying a heavy return feeder to which the other cables can be connected. The size of the return feeder should be calculated without reference to the conducting capacities of the lead covers of adjacent cables, so that the cables will not be relied upon to carry the return current, though, as a matter of fact, they will carry a portion. In other words, the return feeder should be large enough to carry all the "stray" return current, if it were possible to collect it upon the feeder.

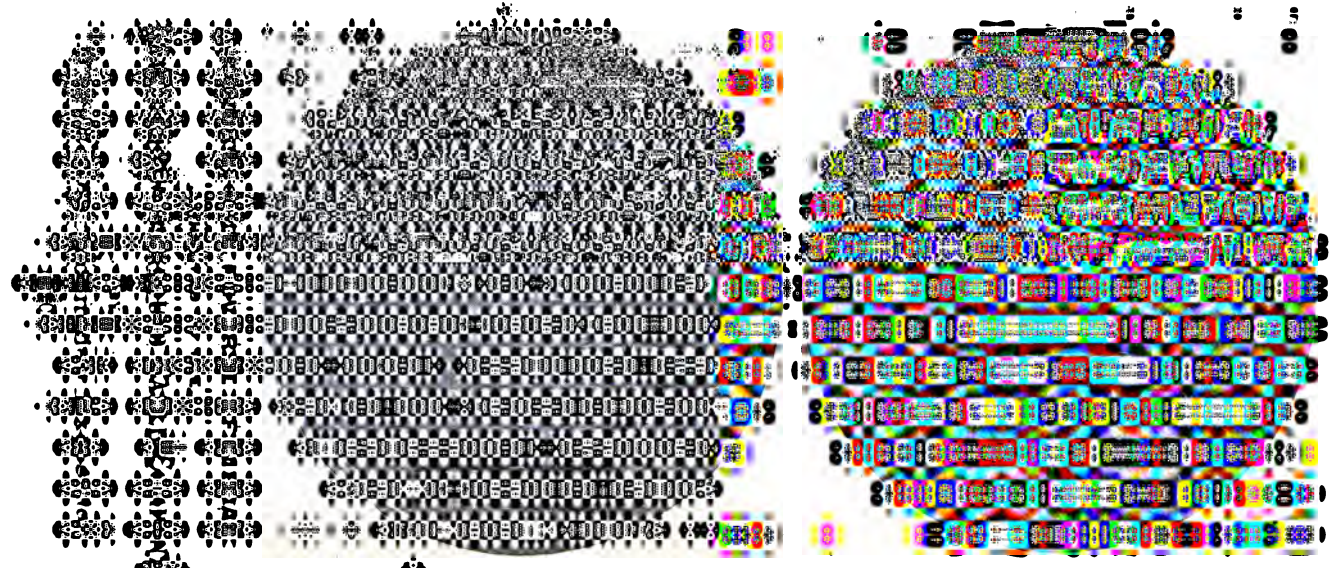
The lead of these cables will very much lessen the resistance of the return circuit, and thus materially benefit the railroad company; while, on the other hand, the other companies who operate lead cables will be to a large extent, if not entirely, protected against electrolytic action. In this way matters might be adjusted much more satisfactorily, and at much less expense, than by the adoption of legal means.

I know of a good many instances where cables that happen to pass near the power-house have been badly eaten away at that point. This confirms my tests; for in these cases the cables have colelcted the current only to return it to earth again at or near the power-house, and hence at this point, where the current left the cable, the harm was done. If the copper return from the cables had been used in these cases there is no doubt but that the cables would be working still.

For reasons similar to those already given there is no doubt in my mind that the life of water and gas pipes would be prolonged by adopting the same plan as is herein prescribed for cables.

HENRY W. FISHER,
Mechanical and Electrical Engineer, Director of Electrical and Chemical Laboratories of STANDARD UNDERGROUND CABLE CO.

Under date of August 1st, 1896, Mr. Fisher confirms the conclusions and recommendations of his preceding report as having been verified by practical experience and further study of the subject. He adds that the points at which to bond the lead covers to the return feeders, and the extent of such bonding, can only be accurately determined by ascertaining the actual potential differences and character in each manhole of a system; otherwise there is likely to be over-bonding in some places and under-bonding in others. In some cases it may be best not to bond the lead to the return feeders, except near the railway power-house, and in some cases such return feeder for the cables should have no connection with the track or the track return feeders. Our patrons will always find us ready to aid them in finding the correct solution of this important and interesting problem as applied to any particular place, and we invite them to consult with us freely.



WORKING DIRECTIONS

FOR

PLACING, SPLICING AND CONNECTING ELECTRIC CABLES.

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INTRODUCTION.

No matter how excellent a cable the manufacturer may produce, if it is not properly installed, and properly cared for thereafter, it will inevitably fail; it is, therefore, appropriate that the manufacturer should indicate just how a cable—especially his cable—is to be laid and cared for, and we will endeavor in the following pages to set forth as clearly and briefly as possible such directions as long and varied experience have shown to be worthy of careful study and implicit confidence on the part of those charged with the duty of laying, jointing or operating underground cables.

Any departure from the methods here recommended, in the case of cables upon which any guarantee has been or is to be given by the Standard Underground Cable Company, will vitiate that guarantee, unless the said company has given its written consent to such departure.

GENERAL INSTRUCTIONS.

Remove the slats from the reels without injuring the cable, and draw out all projecting nails. Avoid making sharp bends or kinks in the cable; let one or two men steady the reel after mounting it on supports or reel cart, to prevent its paying off cable faster than required; turn the reel just fast enough to avoid any strain on the cable; employ enough men to prevent the cable from dragging on the ground. While placing the cables, keep the ends sealed with solder (not tape or compound); handle carefully to avoid puncturing or abrading the lead cover at any place.

In nearly every instance where troubles have developed in cables, they have been traceable to rough usage during or after laying, or subsequently, and to careless jointing.

It should be strongly impressed on the minds of all who are required to handle the cable, that the very greatest care is necessary to prevent the introduction of moisture, and consequent loss of insulation.

It has been found advisable to "ground" the lead cover of both Aerial and Underground Cables, as a means of diminishing inductive action; in the case of electric light cables running parallel and adjacent to each other, the lead covers of the positive and negative legs should be connected at frequent intervals by lead strips securely soldered to each lead cover; the "grounds" and "strips" should be placed every two hundred feet, or oftener where practicable.

For extra precaution against corrosion and mechanical injury see page 78, and page 107 for Electrolysis.

MAINTENANCE.

A ladder should be used for entering and leaving manholes In no case should the cables be used for this purpose.

The moving of cables in manholes should be done, with the greatest of care, one cable at a time. If there is a joint in the cable to be moved or bent, it should be done in such a manner that the joint will not be strained.

Sharp bends in the cables should be avoided wherever possible; if they become necessary the cable should first be heated.

In cold weather, the cables should always be heated before they are moved or bent.

Lead "protectors" should always be kept under the cables, at the mouths of ducts in the manholes.

A regular inspection as to the condition of the manholes, covers, cables, lead protectors, terminals, hangers, junction boxes, and all parts thereof, should be made three or four times a year and carefully recorded, and all necessary work done to keep the entire system at its maximum efficiency.

Whenever a manhole is entered for any purpose, it is advisable to make an inspection of the cables, cushions, hangers and junction boxes, in that manhole.

It should be made the duty of every employe to observe as far as possible, and promptly report any damage or threatened damage to, or anything unusual about, any part of the underground or aerial cable system, for here it is indeed true that "an ounce of prevention is worth a pound of cure."

LAYING CONDUITS.

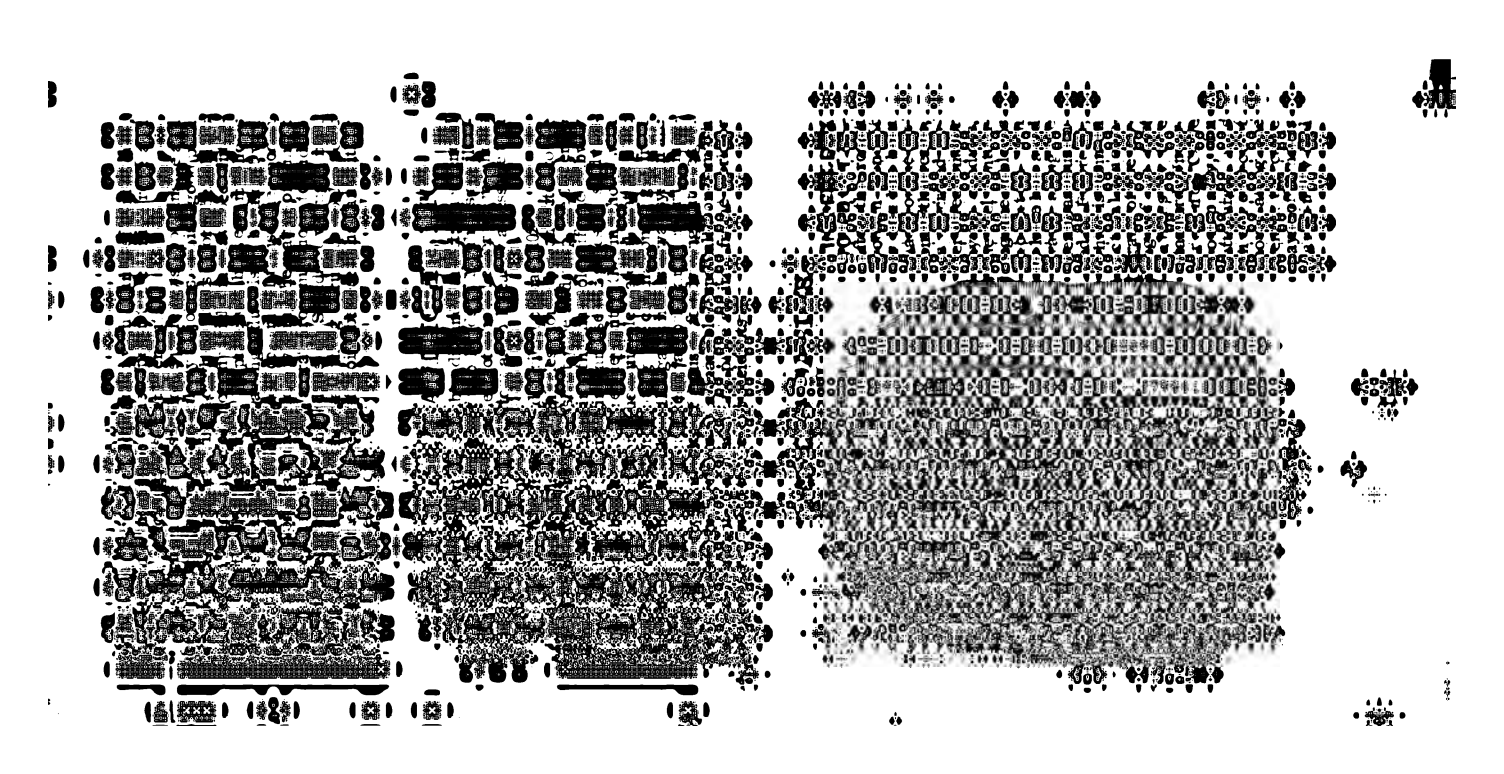
OPEN-BOX CONDUIT. This consists of a wooden box made of one to one and one-half inch rough lumber and large enough to contain all the cables needed; the trench should be opened as nearly straight as possible and the bottom leveled to grade, or at least approximately so; the conduits are then laid on the bottom, the ends butting against each other and held in line by short strips nailed along one side and overlapping six to ten inches on each section; the nails should be of such length as not to pass through to the inside of the box; but a simpler method of holding the boxes in line with each other is to tamp a little earth on both sides of the junction. The box is provided with a strong cover, as further described at top of page 114.

Wherever cables have been carefully laid in conduits of this kind and thoroughly covered with a preservative like roofers' pitch they have invariably given perfect satisfaction. For all ordinary locations, such as underground lines through private grounds to residences, etc., or in cities where it is possible to anticipate future needs with reasonable certainty, no better or cheaper method can be devised, but this is not advisable for all locations, as explained on page 99.

WOODEN PUMP LOG CONDUIT. This is the simplest form of conduit and is laid on the bottom of a prepared trench of requisite depth, by simply butting the ends tight together, the socket joint keeping the conduit well in line.

CEMENT LINED AND HOLLOW BRICK TILE OR MULTIPLE CONDUIT. While these conduits may be laid directly in the ground, a more permanent and satisfactory result will be obtained by observing the following instructions:

Open the trench in straight lines to the required depth so that when all ducts are laid the top layer shall not be nearer the surface of the street than two feet. Level the bottom of trench carefully to grade, but slightly higher in the middle of each section so as to drain water into the manholes, and spread thereon a layer of good cement concrete three inches in depth; on this concrete place the bottom layer of ducts and carefully cover the joints with good cement mortar, which sets quickly and keeps the ducts in line. On this layer is placed a second layer and so on until the required number is laid. The layers of cement lined pipe should be separated by about one inch of concrete, but Hollow Brick Tiles are preferably separated by about one-half inch of cement mortar. Each succeeding layer of ducts should break joints with the preceding one. The top layer and the sides of the conduit are covered, as a mechanical protection, by a bed of concrete three inches in thickness. Fig. 29, page 80 shows the appearance of a subway consisting of twelve three inch cement lined conduits. The Hollow Brick conduits are kept clean during laying by a "Mandril," provided with a cleaning washer, which is pulled through the pipes after the cement has been placed over the joints and allowed to set for a few minutes. If desired a small wire can be attached to the rear



into the box; when all the cables have been laid, the box is filled up with hot pitch which has been melted either in pitch kettles set up along the line of trench, or in an asphalt wagon which is drawn along the edge of the trench as fast as the box is filled from buckets or through a trough or tube extending to it from the asphalt wagon; the cover of the box is then nailed in position and the trench refilled. If the trench is not level the cover should be nailed to the box and the trench refilled—leaving the higher end of the box exposed—and the hot pitch poured in at this end until the box is full. In nailing the cover on the box, be very careful not to drive the nails so as to pass through the wood and injure the cables. At points where future digging may be expected, as at street intersections, a light cast iron cover or shield for the box, is a useful protection.

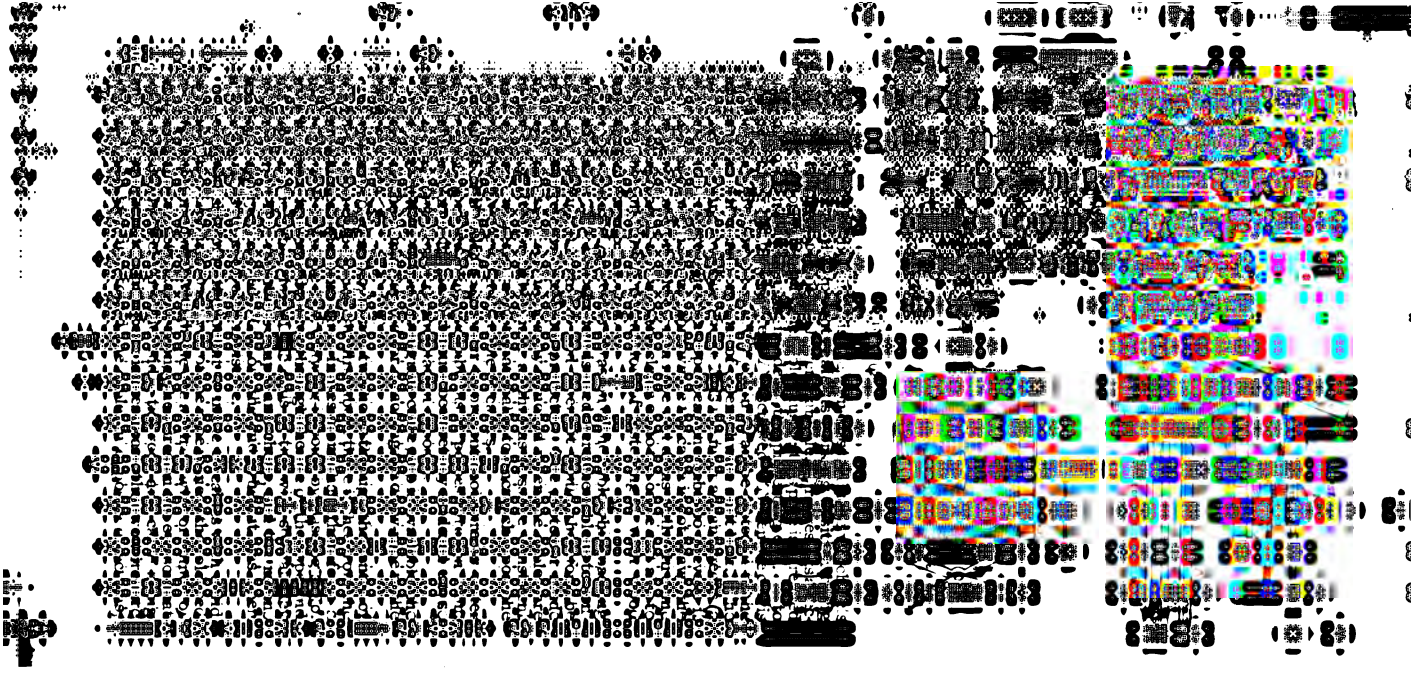
DRAWING CABLES INTO CLOSED CONDUITS.

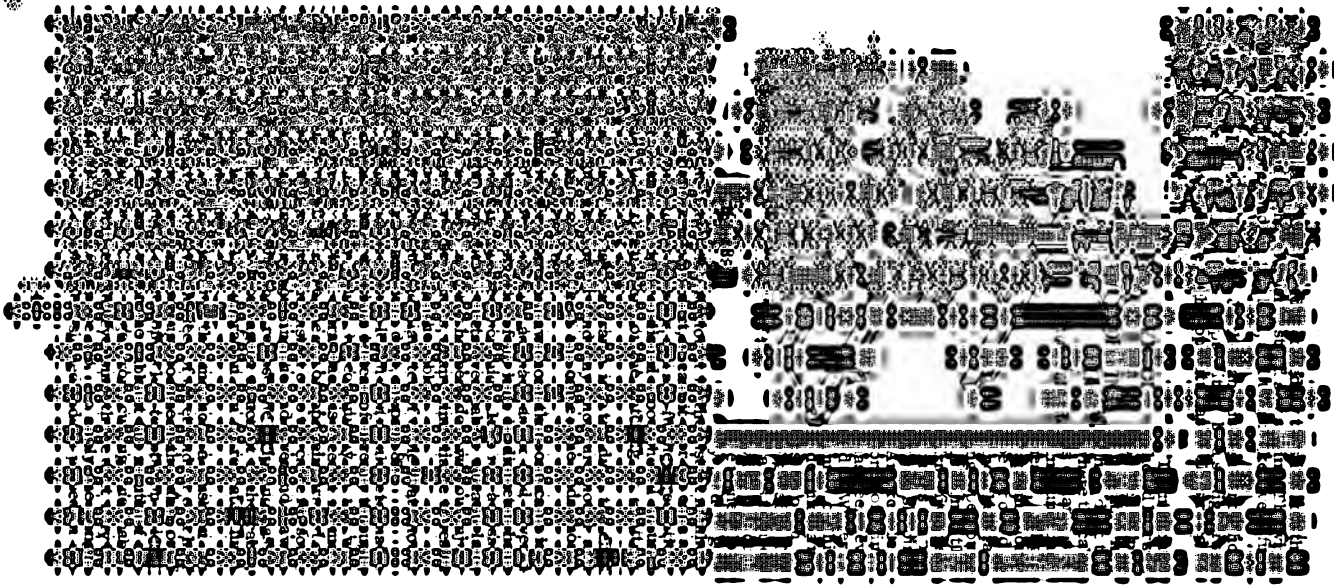
GENERAL REMARKS. Where cables are to be drawn into conduits, too much care cannot be exercised during the work of drawing in; this applies equally to all kinds of conduits, whether iron, wood or cement. See that both manholes and ducts are free from obstructions of any kind; the ducts must be perfectly smooth inside and laid in straight lines between manholes. (See "Manholes," page 101)

RODDING. It is clear that in order to draw a cable into a duct a drawing medium must be placed in the duct; the first step, therefore, is to "rod" the duct; various methods are used, but where the ducts are very smooth and free from obstructions, **a steel wire rod** ¼ inch in diameter is the simplest; as the rod comes off the reel standing near the mouth of the manhole, it is pushed through the duct, comparatively little power being required to pass it through a distance of four hundred to five hundred feet; when the end appears at the distant manhole, a rope is attached to the wire at the entering manhole, and the rod is drawn through, carrying the rope with it, the rope being then used to draw in the cable. The form of rod, however, which is most generally used, consists of four-feet sections of tough wood with brass or iron screw or spring couplings on each end, a sufficient bundle of these is placed in a manhole; the "rodder," stationing himself at the mouth of the duct, pushes one section into it, attaches the second section by screwing it into the first, and pushing it on; this is repeated until the first rod appears at the distant manhole, whereupon the draw rope is attached to the last rod; at the distant manhole the operation is now reversed until the last section of rod has been drawn out and the rope appears. Where a large amount of duct is to be rodded in advance of the actual placing of the cable, it is, of course, impracticable to draw a rope into each section of conduit, and an iron wire is drawn in instead and remains there until the cable is ready, when the first operation is to haul in the draw-rope by means of the iron wire, the wire being then coiled up and utilized again under similar circumstances.

OBSTRUCTIONS. When obstructions are met in rodding ducts, they can generally be removed by mounting a mandril on the first rod, but if this does not suffice, a measurement of the rods that enter the duct until the impassable obstacle is reached, will indicate where the street should be opened over the line of subway to correct the difficulty, which is then done by taking up and relaying a section of the subway; it is, however, very seldom that so serious an obstruction is met.

DRAWING IN THE CABLES. Before drawing in cables with identifying marks and containing more than two conductors, be sure that they are drawn in from that end of a subway section as will result in a perfect correspondence of identifying marks. The cable reel should be placed on that side of the manhole at which the cable enters the duct and the cable allowed to enter the manhole from the top—not the bottom—of the reel, so as to describe a simple curve as shown at *L* in Figure 62. Attach the rope to the cable and draw the latter through the duct. Some of the simplest methods and devices are shown in Figure 62, in which *A* represents a pine plank 6x2, and of such length as will permit of its extending from the bottom of the manhole to about three feet above the surface of the street; it forms part of the sheave shown at *A'*, *B* and *C*; *B* and *C* show the pulley blocks and





slot b, the other end being carried up around the cable and also inserted in the slot, which is made to slope in downwards from the top, so that the hanger, in endeavoring to regain its normal shape, automatically locks itself. The second form consists of a flat metal hanger, as shown at c, c', c'' and c'''; to apply it the T-shaped end is inserted sideways in one of the slots b, and is so shaped, with respect to the slot, that on being turned into its natural position it becomes locked; the cable is then pressed into the mouth of the hanger, which, being resilient, rebounds and locks the cable in.

In lieu of this form, our regular Malleable Iron Cable Hanger, (see pages 85 and 94) can be used exactly in the manner described on page 118, except that it may be found more convenient to substitute staples driven into the side of the manhole, or into a standard or board attached to the side, in lieu of a suspending wire.

DISTRIBUTION.

Having thus provided for the trunk lines, it is also necessary to provide means for placing branch lines for distributing the circuits; some of these will now be described:

CELLAR OR VAULT DISTRIBUTION. From a manhole or handhole located at the most central or easy point of access to a block, a cable having sufficient capacity to serve such block is extended into a vault cellar, and, preferably, to a terminal or distributing box, and thence in both directions under the sidewalks, and, whenever possible, along the walls of cellars or of the vaults under the sidewalks.

HOUSE-TOP AND YARD DISTRIBUTION. The branch cable is extended to a pole centrally located in one of the back yards in the block, or to the roof of a building—in either case to a terminal—and from here air lines are run to each subscriber. For methods of branching and looping cables, see page 122.

STREET-LAMP DISTRIBUTION. To distribute electric light current to street lamps, a subsidiary conduit is laid from the nearest manhole or handhole to the lamp post, the base of which should be hollow and accessible by a door and should connect with the subsidiary duct at such an angle as to offer no obstruction to the entering cable; the two conductors (our Duplex Cables lend themselves most readily to this class of work) are drawn or pushed in.

HOUSE-TO-HOUSE DISTRIBUTION. This somewhat more expensive but strictly underground method of distribution is effected by placing service or flush boxes at every second party line, and there making the necessary branch or "T" joints or placing a junction box when ready to loop in the desired service wires for both houses, unless, as is strongly advised in the case of electric light circuits, or small telephone and telegraph cables (see pages 95 and 97), the main cables are taken in. These service wires or cables are drawn or pushed through the subsidiary ducts from the service or flush box into the basement or cellar of one of the houses, the wires or cables for the adjacent house being passed through the party or basement wall; each cable is provided with a terminal, and extends thence to the lamps, instruments, or other devices by cables or insulated wire. If a service box is used (see page 102) it is necessary to open the street over it whenever it has to be opened for tapping or looping the circuit into the building, or for repairs or changing the connections, but this cannot be avoided (except by using a flush box) as it is impossible to predict in advance what service will be required in any given block when the subway is first laid; nor is such opening any more objectionable or difficult than the current practice of gas and water companies in providing service lines.

LAYING SUBMARINE CABLES.

We frequently furnish short cables for crossing rivers or narrow lakes, bays or bayous, and while it is impossible to give instructions that will apply to all cases, yet a simple method of laying such cables may be suggested, which can be modified to suit the circumstances of each case.

The cable is always shipped on strong wooden reels of suitable size; procure a boat or flat of proper capacity to carry the reel and attendants in safety; through the centre of the reel pass a crow-bar or piece of round iron and mount it on trusses near the bow of the boat, so that the reel will revolve as the cable pays out; station a man on each side of the reel to regulate the speed

with which it revolves, as otherwise it may pay off cable faster than the boat moves away, which would probably result in injury to the cable; let the cable pass off from the bottom of the reel. The cable should be carefully watched as it pays out and should be guarded from rubbing against any sharp edges or rough surfaces; a few pieces of old carpet or coffee sacks spread over the end of the boat where the cable passes off may prevent the destruction of the cable. Before leaving shore, the end of the cable should be firmly secured at the point where it is to meet the pole line or underground cable; in doing this it will hardly be possible to avoid injuring three or four feet at the end, as it may be necessary to wind it around a post or tree to hold it fast when the boat moves out. An inspection will usually show whether or not it has received any injury, but, as a rule, if you have any doubt, especially in the case of cable for conveying high tension currents, it is best to cut off enough of the cable to insure the removal of any injured or compressed portion.

The boat should move at a slow speed and should land with prow towards the shore near the point where the cable is to land; then continue slowly and carefully unreeling the cable and dropping it into the water along-side of the boat, being careful to hold fast to the end and at all hazards prevent it from getting wet; then extend the shore end of the cable to the point at which it is to meet the pole line or underground cable.

If the cable is light and only a few hundred feet long, and the bed of the stream is free from stones or other objects that might cut the cable, the above plan may be reversed, *i. e.*, mount the reel on the shore, take the end of the cable into the boat and carry it across the river to the desired point.

The shore ends, are, of course, to be laid in a trench extending down to the water's edge, and if, on account of a low stage of water, or the practicability of using a dredge, it is possible to bury the cable for some distance out in the bed of the stream it will be an additional assurance of the long life of the cable, as in that case the danger of vessels running upon and crushing it when landing, will be reduced to a minimum. It is generally advisable to put up a prominent sign, giving notice of the "Cable Landing."

In case the lead cover should be broken in process of laying, examine it carefully to see that there is no moisture present, and then make a careful solder-wipe over the break; if any moisture is present, follow the directions given on page 122, except that the cable must only be cut as a last resort, in which case cut off enough at each side of the break to insure entire freedom from moisture; then re-unite the two ends as directed under the head of jointing, on pages 126 and 127; the additional protection (if any) over the lead cover must be restored and extended over the splice, so as to make it a continuously protected cable.

STRINGING AERIAL CABLES.

(See figure 64 and page 85.)

Fig. 64.

Place the suspending wire, solid or stranded, in position, taut, avoiding wire splices between poles, and securing the ends against possibility of coming loose when the weight of the cable is added; if the cable is unusually large and heavy it is best to use a wire rope having the necessary tensile strength.

Stretch a "leading-up" wire from ground to starting pole, at a gentle incline, and connecting with the suspending wire. Station men with block and tackle at the point to which the section of cable is to reach, allowing the rope to rest on the cross-arms and pass down to the cable at the end of the "leading-up" wire; secure the rope to the cable end and let it be drawn along slowly and smoothly, or as fast as the cable hangers can be attached to the cable as it passes off the reel and up the "leading-up" wire; attach the hangers to the cable 4, at intervals of 24 to 30 inches, as at 3, by means of the tongs described on page 135 but engaging only every fifth or sixth hanger to the "leading-up" wire, or to the suspending wire, 2, until the last span is reached, when every hanger must be hooked, 1, on to the suspending or messenger wire, as it passes the lineman on each pole, so that when the cable is drawn over the last span into exchange or to pole terminal, the whole will be hooked up.

The method just described has several disadvantages. The strain on the hangers in sliding up the inclined wire, and then along for eight or nine hundred feet on the horizontal messenger wire, tends to loosen them on the cable whereupon they slip from their places and two or three hangers become bunched at one point, while in between the cable hangs in loops, rendering it necessary for a man to go out on the wire to space the hangers. A system which overcomes these disadvantages has been developed and patented by our General Superintendent of Construction, Mr. F. S. Vielé. While our method secures more satisfactory results in the appearance of the finished work, it, at the same time, materially reduces the cost of installation as will be seen from the following description.

The inclined wire is strung as previously described and hangers are applied to the cable in the usual way.

The rope by which the cable is to be pulled up is securely fastened to the end of the cable and passed along the line, resting at every cross-arm on Idler pulleys, shown in fig. 64 A.

A carrier, A, B, C, of fig. 64 A, consisting of grooved wheel, A, pivot B, and supporting stirrup C, is then placed on the inclined wire, and the end of the cable with hangers on it, is placed in the angle of the stirrup. The stirrup being shaped so that any size cable will be closely held without slipping, one carrier will serve for all sizes of cable.

The cable supported by "carriers" is pulled up the inclined wire, carriers being placed every thirty or forty feet, depending on size and weight of cable.

When the horizontal wire is reached the cable passes over an Idler pulley, and a man at the pole moves "carriers" from the inclined wire to the messenger wire, and the cable then runs

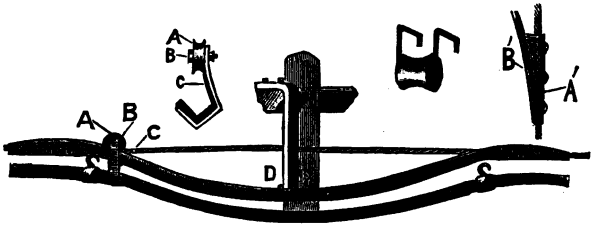


Fig 64 A.

along on the messenger with only the little friction due to the wheels of the few carriers, thus moving much more easily and rapidly, and with far less strain on the cable and less men to pull it, than when many hangers are slipping along on the wire. When the carrier comes to a cross-arm, a switch shown at A', engages the wheel, and deflects it far enough to clear the messenger wire, and then guides the cable down far enough to pass under the cross-arm, reversing the direction when the arm is passed, and guiding the pulley up on the wire again. The switches proper, (patented) are composed of two parts bolting around the messenger, and eight inches in length. One half of the clamping device, A', has on it the rib, B', which raises the wheel of the messenger wire, and deflects it to one side, The rib is continued between clamps, by a wrought iron bar, (shown in fig. 64 A), three feet long, which dips sufficiently to allow the pulley to pass under the cross-arm, then rises and shunts the pulley back on to the switch and thence to the wire. A pivoted support D, at the middle of the iron bar, passes over the cross-arm and prevents the weight of the cable from dragging the bar down so that the pulley will run off.

One man can keep ahead of the cable gang with the attaching of these switches. The bar may be made of different shapes, such that the pulley can be passed under or over the support on either side of a pole, or to one side of the pole, if fastened to the pole itself.

When the cable is all pulled up in position, except the last section, men stationed at each pole, place the hangers themselves on the wire, remove the carriers as they reach the pole, and the last section is pulled into position, leaving the cable permanently in place. It is evident that the men usually necessary on poles *all* the time, are with this method available for other purposes, as applying hangers, etc., a large majority of the time, hence the force of men may be reduced considerably; and

furthermore, the strain on the hangers and cable is greatly reduced, the hangers only sliding on the wire the distance of one span, instead of the whole length, as heretofore.

Our experience with this method has proved its superiority over any yet brought to our attention, and we heartily recommend its adoption by those who have much aerial cable to install, and prices will be quoted on application, for the devices, or the right to use them.

Measurements of aerial cable should always be made so that joints shall come at poles, and not in the middle of sections.

Platforms and steps should be permanently placed on all poles where terminals are located, so as to facilitate regular inspection of the apparatus.

PLACING CABLES OR WIRES IN MINES.

To pass from the shaft house to the levels at which the electric current is to be delivered, attach the cable to the timbers of the skips or elevator guides by such of the means described under "House Cabling or Wiring," page 121, as are best suited for the case; some of these are illustrated in Figure 65, next page.

If the entry is horizontal, or but gently sloping, lay down a rough wooden box, place the cables therein (see pages 112 to 114) and, unless there is considerable danger of chemical actions, do not fill the box with pitch; then replace the heavy plank cover and secure it firmly to the box. Be careful not to injure the cable or insulation in handling it or in fastening down the cover. For mine work it is advisable to give the cables the extra protection of a saturated fibrous cover described on pages 78 and 79.

The box suggested is inexpensive, and can be made so small as to be but slightly, if at all, in the way, and affords a proper protection to the cable against the possibility of mechanical injury.

An alternative in horizontal or gently sloping entries would be to suspend the cable overhead or on the sides of the entry, as described on page 118, the suspending wire being secured by spikes or rods driven into the walls or sustaining timbers at suitable intervals.

Where the cables branch off into the various levels or rooms, the connection between the main and branch cables should be made in a weather-tight terminal box or cut-out box, as described on pages 89 90 and 182, so that the connections can be readily changed when desired, or better still, use a regular junction box.

The branch cables can be laid in a rough box or suspended as above described. Do not fail to provide each cable end with a terminal to protect the conductors against moisture. If these methods are carefully followed, satisfactory results will be certain.

Another plan, but more expensive than either of those suggested above, is to use iron armored cables such as are employed in submarine service; these could be laid on the floor of the entries or levels, and would not be easily injured.

If a cheaper class of wiring is desired than could be done with cables, and the mines are comparatively dry, use our Weatherproof Line Wires—especially the Tip-Top grade, (page 20)—but if the mine is in a constantly moist or wet condition, use a suitable Rubber-covered Wire (pages 11 to 13); the wire should be tied, in the usual way, to glass or porcelain insulators mounted on brackets, the brackets being secured to the sustaining timbers or walls.

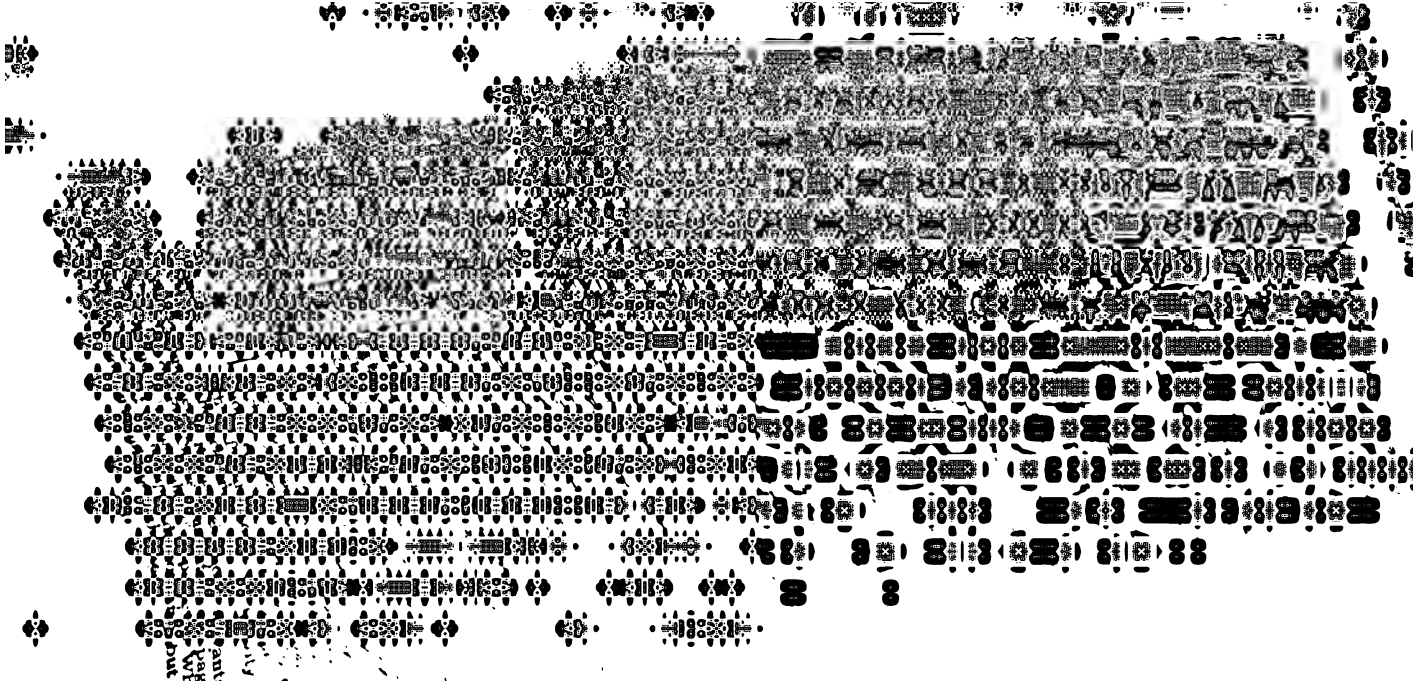
For instructions for making joints, loops, etc., see pages 122 to 130.

For Flexible and Duplex Wire to connect from the permanent circuits to movable lights, drills, etc., see pages 11, 14, 21.

HOUSE CABLING OR WIRING.

For determining the size of conductor to be used in wiring a building for electric lighting see rules and tables, pages 165 to 171 inclusive; for the general character of the work be governed by the rules of the Board of Fire Underwriters.

In order to obtain the best and neatest results, architects and owners of buildings in process of erection should make ample provision for electric wiring for lighting, annunciators, call bells, etc., and this can be done at small cost; passages or channels of suitable size, say from one to two inches square, should be left to all points at which it is likely that a lamp, annunciator, push button, etc., might at any time in the future be located; proper openings should be left through the partitions at suitable places between ceiling and floor; the "risers" through which the wires or cables are passed from one floor to another should be ample in size. It is advisable to insert at a suitable point in the wainscoating of each floor a neat box provided with lock and



MAKING JOINTS, LOOPS, ETC.

GENERAL INSTRUCTIONS. The greatest care is necessary in making joints or connections on cables; if properly made they are fully as good as the cable itself.

This is the most important part of a cable installation; given a strictly first-class cable, its practical success or failure is dependent upon the method and care used in making the joints. This part of the work must not be entrusted to inexperienced or careless hands; every splice should be carefully inspected by the superintendent in charge before being passed. Let all buyers take notice that any important deviation from the instructions given in this book for making joints will vitiate any guarantee that may be given by us, unless our written consent to such deviation has first been procured.

Do not undertake to make joints on our cables in any other way than hereinafter described, without first submitting the proposed method to us for approval; it is at least possible that your "new" method has been long ago tried and found unsafe, and we will cheerfully give our customers the benefit of the information accumulated in the past thirteen years

Put the insulating tape or covering on the wire joints to at least the same thickness as the regular insulation of the cable conductor; be sure that there is no protruding sharp burr or point on any of the wire splices, as it may subsequently be forced through the insulation to the lead sleeve, or to another conductor, causing a "ground" or "cross"

The wire joints may be made and insulated by an expert lineman, but, unless he has had special experience or understands the manipulation of the Joint Moulds, he should have a first-class plumber to prepare the sleeve and make the solder wipe, etc. The splicer's hands must be kept perfectly dry and free from perspiration, as a little moisture communicated to the splice may result in lowering the insulation resistance.

It is a matter of record that all the burn-outs occurring in electric light cables in the New York subways in a period of twelve months (with the exception of those in a Vulcanite Insulated Cable) were traceable in every case to **defective joints**, or to mechanical injury; it pays to employ good jointers in underground work, and if you cannot secure absolutely reliable and experienced men, we are ready to furnish them. There have been several important instances in this country where the idea that any one could make joints and that any kind of joints would suffice was not only held, but acted upon, by those who should be supposed to know that the reverse is true, the result being the partial if not complete ruin of the cables.

William Maver, Jr., says on this point (see foot note, page 72):

"If, for example, the method of making joints that it is related was employed some years ago in Philadelphia—namely, to strip the ends of the lead covering for two or three inches and then to place three or four turns of tape around the ends of the conductors—had been followed in the New York subways * * * * I think, no doubt, I would have had to report to-night a continued series of failures in the electric light service similar to those so often quoted as having happened in Philadelphia."

Each section of cable should be carefully tested (see page 137) for continuity and insulation before making the wire splices, and again when the joint is finished.

GENERAL DIRECTIONS FOR MAKING JOINTS AND USING TOOLS, ETC.

REMOVING MOISTURE. The first step in making a cable joint is to cut off the soldered end and inspect carefully for indications of moisture; if any moisture is present and is thought not to extend very far from the end, cut off a little cable at a time, inspecting carefully after each cut; *be careful not to continue this so far that the cable will become too short to be jointed.* Whether or not these cuts have removed the moisture can be determined by removing the lead from the piece last cut off and dipping it into very hot insulating compound; if any moisture is present it will be evinced by bubbles rising to the surface; if these bubbles appear when no more cable can be cut off, apply heat to the lead cover of the cable, beginning at the point nearest the duct and very slowly approaching the end of the cable, the object being to drive all moisture to the open end; wherever it is allowed, a furnace or torch can be used for this purpose, and if the cable is covered with saturated fiber, a metal screen or net should be interposed between the flame and the cable to prevent

cylinder *b*, which corresponds closely to the diameter of the insulated conductor and fix it firmly by the set-screw *d*, then adjust the limiting screw *f*, so that the cutting blades *a* will be prevented from making contact with the sides of the groove in the cylinder *b*: insert the end of the insulated wire between the blades and the groove, allowing it to pass in as far as the tool will permit: then press the handles together to the limiting screw, and holding the wire firmly with one hand, draw the tool away from it with the other; this removes the insulation from both sides of the wire and cuts through the layers so that the remainder can be removed instantly by the fingers; the blades should be oiled freely so as to facilitate the cutting.

The tool regularly furnished is designed to cut the insul .tion from the wire for a distance of only one inch, which is ample for any conductor smaller than No. 12 B. & S. G. If it is desired that the tool shall cut off more than this amount, a slightly modified form will be furnished.

If the conductor is larger than No. 10 B. & S. G. the lead-cutting tool shown in Fig. 55, page 105, is well adapted for the purpose and can be operated in the manner described for removing the lead from anti-induction cables, but in that case the cutting depth of the blades should be adjusted to slightly less than the thickness of the insulation, else the blades might strike the conductor and soon become dulled. The better way is to adjust the stops and place the tool as above described for cutting the lead off large round cables, and after closing the jaws on the insulation, revolve the tool directly around the wire.

WIRE SPLICES. The fifth step is to make the wire splices. Several tools have been designed by us for making splices on telegraph and telephone cables. (Splices on electric light cables are described in a subsequent paragraph.) One of these:

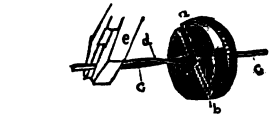


Fig. 67.

THE ROTARY WIRE SPLICER, is shown in Figs. 54A and 67, and its operation is as follows: Bend the left hand wire *d* at right angles to itself, the bent portion to be approximately equal in length to one-half the diameter of the splicing tool, or about the width of the jaws of small cutting pliers; insert the bent portion through the slot *a*, into the hole at the bottom of the slot, the outer end of which is shown at *b*, its course through the tool being indicated by dotted lines; then lay the right hand wire *c*, into the slot upon the wire *d*, to which it is to be spliced, and extending beyond the tool far enough to be conveniently grasped with the pliers *e*, say from one-half to one inch, according to the size of the wire, a longer splice being desirable for larger wire; grasp the two wires at the left hand side of the tool (Fig. 67 shows this stage), and then revolve the tool upon the wire as its axis and gradually draw it away from the pliers until the wire inserted in the hole *b*, has been entirely withdrawn. Fig. 68 shows the finished splice as produced by this tool. From four to six revolutions of the tool will be sufficient to make a perfect joint with the wire ends proportioned as here described; fewer revolutions mean the more rapid movement of the tool away from the pliers, while more mean a slower movement, but the jointer can easily regulate the movements, so that from four to six turns will complete the joint; this will be found to be the best practice, as fewer turns might result in a loose joint, and more turns might twist the wire so hard as to break it off. With a little practice however, it will be found that the tool practically regulates itself and needs no special attention. The splice can be made longer or shorter by lengthening or shortening the ends of the wire from the proportions above given. It is important to keep in mind that the tool must be revolved to the right, that is, as the hands of a clock move, otherwise there is danger of breaking off the wire. When the joint is finished, see that both ends are pressed down by the tool or pliers, so as to leave no sharp points to pierce through the insulation. Another tool, the

Fig. 68.

WIRE SPLICING TONGS, is shown on page 105, Fig. 57, and its operation is as follows: Slip the copper sleeve into the groove *a*, between the anvils *b* and *c*, so that the inter-locking portions will be on the outside; now insert into the sleeve, from opposite

sides, the two wires that are to be spliced, allowing them to overlap each other and extend about 1-16 inch beyond the ends of the sleeve; press together the handles of the tool with sufficient force to cause the milled surface *f* to press

Fig. 69.

the tongue of the sleeve hard into its corrresponding groove; this completes the joint, the tool is easily removed by spreading the handles apart; the position of the wires and sleeve in the jaw of the tool, just before the milled surface *f* has closed upon them, is shown in Fig. 69, the completed joint being shown in Fig. 70. See that the sleeve and re-

Fig. 70.

moveable parts *b* and *c* of the tool are the correct size for the wire which is to be spliced; for instance, the removable parts and sleeve adapted for a No. 14 B. &. S. G. conductor should not be used for making a splice on No. 16 or No. 18 B. & S. G. conductor; removable parts and sleeves will be furnished when required for any size conductor. See table on page 106.

INSULATION. The sixth step is to insulate the conductor, for which full instructions are given in a subsequent paragraph.

COMPLETE OR SLEEVE JOINTS. The seventh step is to make a complete solder joint or sleeve joint over the insulated conductor or conductors, and this may be done by the old method described further on, but in the search for quicker methods we have devised two moulds which give very satisfactory results, and which can probably be used with entire success. If the moulded joints are carefully inspected by the superintendent in charge and the workman compelled to exercise proper care, an absolutely safe joint can be produced.

A careful following of the instructions in an intelligent manner, will make the use of this device of great value especially where skilled plumbers or jointers are not available, as in places remote from cities where skilled underground cable workmen can be found.

The Complete-Joint Mould (page 108) is intended for making a complete joint at one operation, and in this no lead sleeve is required. This form of mould can only be used where the cables contain but few conductors and where the insulated wire joints do not require to be spread over a considerable length in order to form a bulk slightly less in diameter than the cable itself. It is operated as follows:

The amount of lead to be taken off the cable largely depends on the size of the cable; if too much lead is removed, there will not be enough bearing surface for the paper tube.

For No. 4 Electric Light Cables with 6-32 inch insulation, strip the lead back on each end 13-16"; remove the insulation for a distance of ½" from the end of the wire, this gives a wire joint one inch long. Commence to tin the cable ends 5-16" from where the lead has been removed and tin back ½". This will serve as a general guide for proportioning the various parts of a joint; the mica sheet increase slightly in length with the size of the conductor.

Figure 71 shows a section of a complete joint on No. 4 B. & S. G. Electric Light Cable. The scale is half actual size.

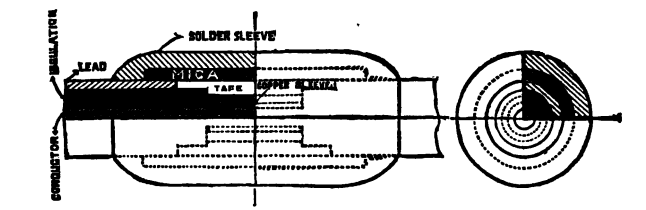


Fig. 71.

See that the removable parts are of the right size to fit the cable and the mica tube, and that the mica snugly fits the cable. The sheet of mica should be about $\frac{1}{32}$ of an inch thick, and free

and the lead. If the insulation is thick, as in Electric Light Cables, cut it to taper like a pencil point, as at *d*, Figure 74, to secure a more perfect union between it and the insulating cover of the splice;

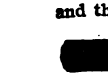


Fig. 74.

SCRAPE THE CONDUCTOR bright, and if a sleeve joint is to be made, slip the

LEAD SLEEVE, previously prepared, (see page 104) over one of the cable ends and push it back out of the way, while the conductor is being jointed and insulated; the

Fig. 75.

WIRE SPLICE, if on a conductor smaller than No. 8 B. &. S. G., is then made as above described, or the regular United States Telegraph Splice, shown in Figure 75, may be made.

When the conductor is No. 8 or larger, and especially if composed of strands, as in most electric light cables, the following method is used, viz: Referring to Figure 74, the ends of the conductors *a a'* are cut square across, butted together, as at *b*, and soldered in this position; a piece of sheet copper is then pressed around the junction and firmly soldered in place, an opening being left along one side of the sleeve, so as to allow the solder to catch the copper strands; or a copper tube, *c*, snugly fitting the bare conductor and having an opening in the top, as shown, to admit solder to the copper strands, may be used in lieu of sheet copper. Solder heated to the same degree as in making a wiped joint is then poured over the copper sleeve and the surplus caught by the wiping cloth, until the solder is thoroughly sweated into the splice, and the sleeve and conductor are strongly united.

INSULATING THE SPLICE. A tape of cotton or paper according to the insulation of the cable is then wound spirally around the wire connection until it is protected by three or four ply of the tape and to at least the thickness of the insulation on the conductor. In lieu of tape the tubular braid, described on page 102, or a tube of paper in case of paper insulated telephone cables, may be used, the tape or tube should cover both the wire splice and exposed section of the insulation, *d d'*, and should be held in place by a tie of strong thread, or, if the tape is used, it can be split in half for a short distance from the end and the two halves brought round in opposite directions and tied, as shown in fig. 79, now pour hot insulating compound over the splice to expel any moisture that it may have taken up from the jointer's hands or from humid conditions of the atmosphere or manhole, holding a vessel below to catch the surplus.

For Rubber Cable see page 130.

WIPED SOLDER JOINT. The lead sleeve is then brought up, so as to bring the centre of the sleeve coincident with the centre of the wire joint, and the ends of the sleeve are dressed down close to the lead of the cable and joined thereto by a wiped **solder joint** (B, Fig. 76); the wipes must be absolutely water-tight, and should be carefully made and inspected.

FILLING THE SLEEVE. The sleeve is then filled with hot insulation through a hole tapped for that purpose in the centre top of the sleeve, except in the case of a large cable, or cables containing many conductors, when two holes should be tapped (see Figure 76), each about one-third of the distance from the ends and hot insulation poured alternately into these holes until the sleeve is thoroughly filled. Plenty of time should be given the compound to saturate the tape and drive off any moisture that may have been communicated by the workmen. This is an extremely important matter, and low insulation, and possibly re-making the joint, will be avoided if a little more time and care be given to the proper filling of the sleeve. Should there be any indication of moisture when the insulation is poured into the sleeve, it should be elevated at one end, so that as the compound is poured in one hole, it will run out at the other and carry off all the moisture. The amount that overflows should at least equal that required to fill the sleeve. The overflow is received in a vessel and used again for other joints. When the sleeve has been completely filled, the holes are closed by sheet lead caps soldered carefully over them,

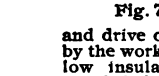


Fig. 76. Sleeve Joint.

and the joint is then complete. It should not, however, be moved or have any strain put upon it until it has cooled.

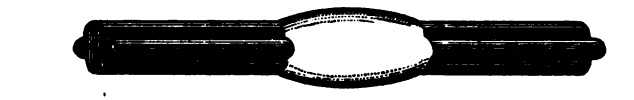


Fig. 77.

In lieu of making the sleeve joint just described, a **single wiped solder joint** (see Figure 77) may be made on the insulated conductor, but in this case, unless the complete joint mould above described is used, a thin and narrow strip of sheet lead should be wound spirally upon it with slightly overlapping edges from cable-lead to cable-lead, after pouring hot insulation on the covered splice.

JOINTS ON ANTI-INDUCTION CABLES.

The same general method is followed with each conductor as in the case of small single wire cables, above described. Each insulated wire may be separately wrapped with thin sheet lead from the lead on one side to the lead on the other, to preserve continuity of the anti-induction feature, before making the complete wiped joint or centering the sleeve for a sleeve joint; if the separate wraps of sheet lead be omitted and a single complete wiped joint is to be made, it is necessary to fold an overlapping strip of sheet lead lightly around the bunch of insulated conductors, so as to form a metal body or core on which to build the wipe. Before making the wire-splices be sure that the indentifying marks, on the two cable sections, register with each other.

JOINTS ON BUNCHED CABLES.

In making joints on bunched cables of less than fifty wires, proceed as in anti-induction or small single wire cables, but omit the use of sheet lead. If the cables contain fifty wires or upwards, distribute the wire splices and avoid the bunch which would result from making them all opposite one another.

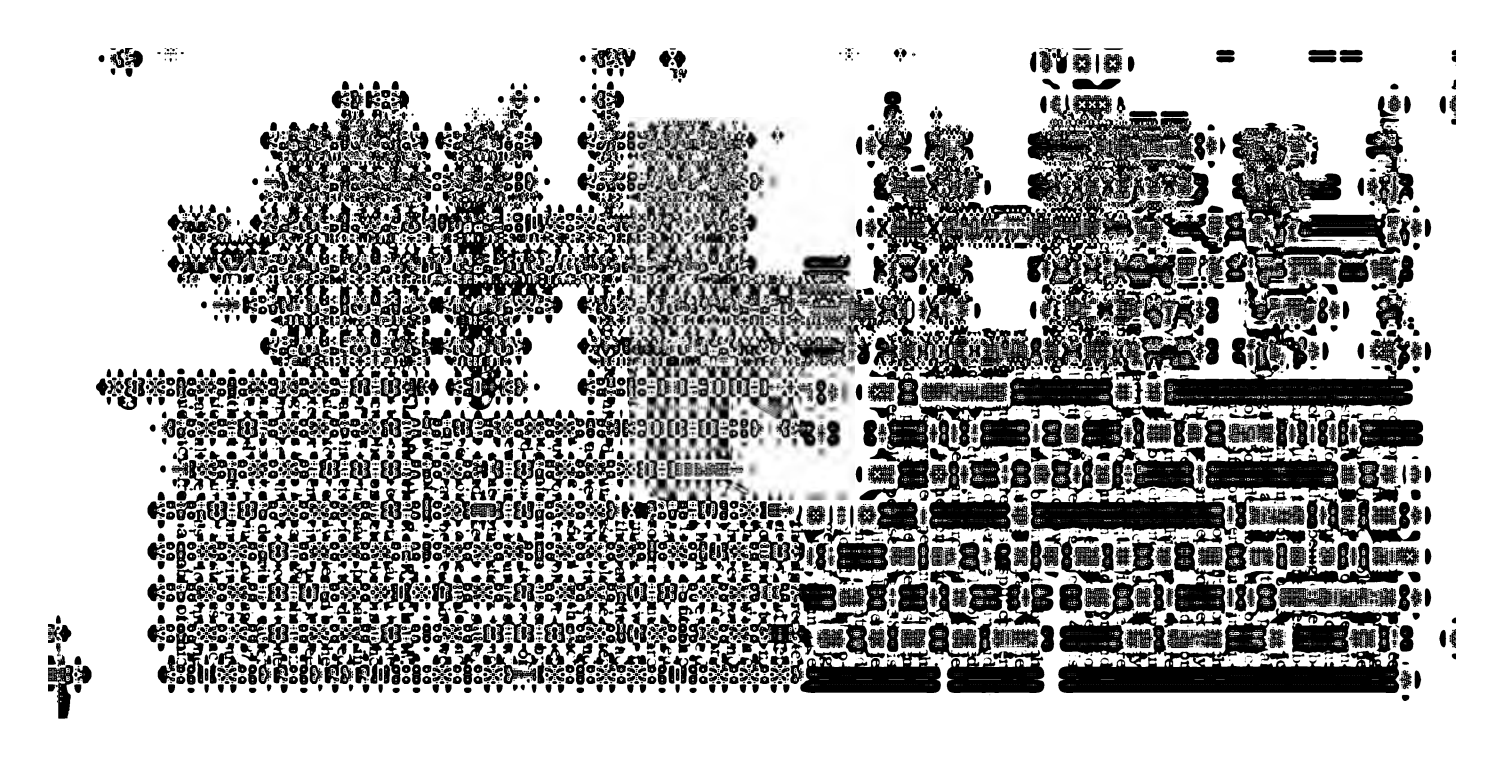
The following description of jointing a two hundred conductor cable is applicable to all multiple cables of this class:

Strip the lead off for a distance of two feet from the ends of the cable and separate the conductors into eight groups of twenty-five wires each. Select that group that lies principally on the top or upper side of the core, and cut the wires off within three inches of the lead. Then take the group on either side and cut the wires off six inches from the lead. Follow this plan all the way around, making each group six inches longer than the preceding until the last bunch is reached, which will be found to be the proper length without cutting. Prepare the conductors of the other cable in exactly the same manner, but in the reverse order of rotation, which will bring the shortest ends of one side opposite the longest ends of the other; the three-inch ends of one side should then meet the twenty-one inch ends of the other, and so on, the lengths dove-tailing to one another so as to give an equal distribution of the eight groups of wire joints throughout the twenty-four inches. The ends of the conductors are then cleared of insulation, connected and wrapped, as in the case of the small single wire joint. Pour hot insulation over it, so as to expel all possible moisture; the bunch of wires should then be pressed compactly together and tied with a strong, thin cord, or wrapped tightly with a piece of cotton tape from one end to the other; then centre the lead sleeve and proceed as described above for electric light cables, noting carefully the extra precaution as to two pour-holes instead of one, and giving ample time for the absorption and settling of the hot compound.

LOOPS, HALF-CONNECTIONS, ETC.

From the foregoing directions for making electric light and small single wire and bunched cable joints, the following brief directions for making loops, half-connections, etc., will be easily understood:

LOOPING ELECTRIC LIGHT CABLE. Figure 78 illustrates a loop from a Duplex Electric Light Cable before the splice has



kind, a two-wire cable being used for the loop; *a* is the wire splice; *b* is the same taped; *c* is the regular insulation; *d* is the branch cable. After the wire splices have been insulated, the entire connection is enclosed in a lead Tee precisely as in the electric light loop above described; substantially the same method is followed for looping out any number of conductors from the cable.

See page 88 for a method that obviates the making of any joints in looping, branching or dividing cables, whether they be underground or aerial, except that in the latter case the cables are brought into the bottom of the cable box from the cross-arm or other support. Thus if a 100 pair cable were to be connected to 2-50 pair aerial cables, at a given point the three cables would enter the cable box, the 100 pair cable in the center and one of the smaller cables on each side of it. Each would be provided with a terminal and each of the 50 pair cables would connect to 50 pairs of the main cable by short jumper wires between the proper binding posts. The method described in the next paragraph is however, a strictly "underground" method of

SPREADING OR DIVIDING. If a 100 wire cable is to be divided into, say a 30 or a 70 wire cable at a given point, treat the cables of the latter denomination as forming one side of a regular cable joint, and proceed accordingly; if a small cable is to be divided proceed substantially as if making a joint on anti-induction cable. A cable spread into single conductor cables is shown in Figure 88.

Fig. 83.

MULTIPLE JOINTS. In telephone work particularly it is often advisable to be able to reach a wire at two or more points; to accomplish this end the main cable is joined "in multiple" with smaller branch cables. For instance, a 100 pair cable may have twenty-five pairs taken off "in multiple" at two or more places, so that if subscribers increase in one place and decrease in another the changed conditions can be met without any further change in the cable system than to "dead-end" or open the surplus circuits at the reduced points and utilize them at the other. When this kind of a joint is made, the 100 pairs are joined straight through and twenty-five of the pairs are also connected in multiple with twenty-five pairs of a smaller cable, going to some distributing point. In this case the paper tube (Insulating the Splice, page 127) covers the splice of the three wires instead of two as ordinarily. If pairs 1 to 25 were jointed in multiple at one point, 13 to 38 would be taken at the next, 26 to 50 at the next, etc.

INSULATING THE SPLICE ON RUBBER CABLE. On rubber insulated cables the copper conductors are joined exactly as described for cables insulated with fiber or paper and the wire splice is then covered by a thin layer of pure unvulcanized rubber tape $\frac{1}{64}$ to $\frac{1}{32}$ in thickness, wrapped spirally round the splice and this layer again covered by tapes, until the insulation is as thick as on the main conductor. The tapes contain less and less rubber until the outer layer is reached and this is usually a first-class adhesive cotton or linen tape. When the cables are lead covered the rubber tapes do not require vulcanization, as the lead cover is air tight, but on aerial or other non-leaded cables, the rubber should be carefully vulcanized by means of heat, applied by a spirit lamp or other suitable device and then covered with the linen or cotton tape as a mechanical protection. The vulcanizing of non-leaded rubber cables is a very important feature, and should be intrusted only to skilled experts, if satisfactory results are to be obtained, and the cable is to last any considerable time.

SPACING AND SEPARATING DEVICE. The Marsh patented method of spacing conductors in multiple electric light cables is useful and desirable in many cases, and consists of an insulating block or disc having the requisite number of grooves in its periphery, into which the spliced conductors, whether bare or insulated, are placed; the lead sleeve is then applied and filled with compound as usual. It prevents any possibility of crowding the conductors against each other in the sleeve, and so insures greater separation and higher insulation at the joints.

JUNCTION BOXES.

Read carefully the description of the junction boxes on pages 95 to 98, so that the following instructions may be more readily understood.

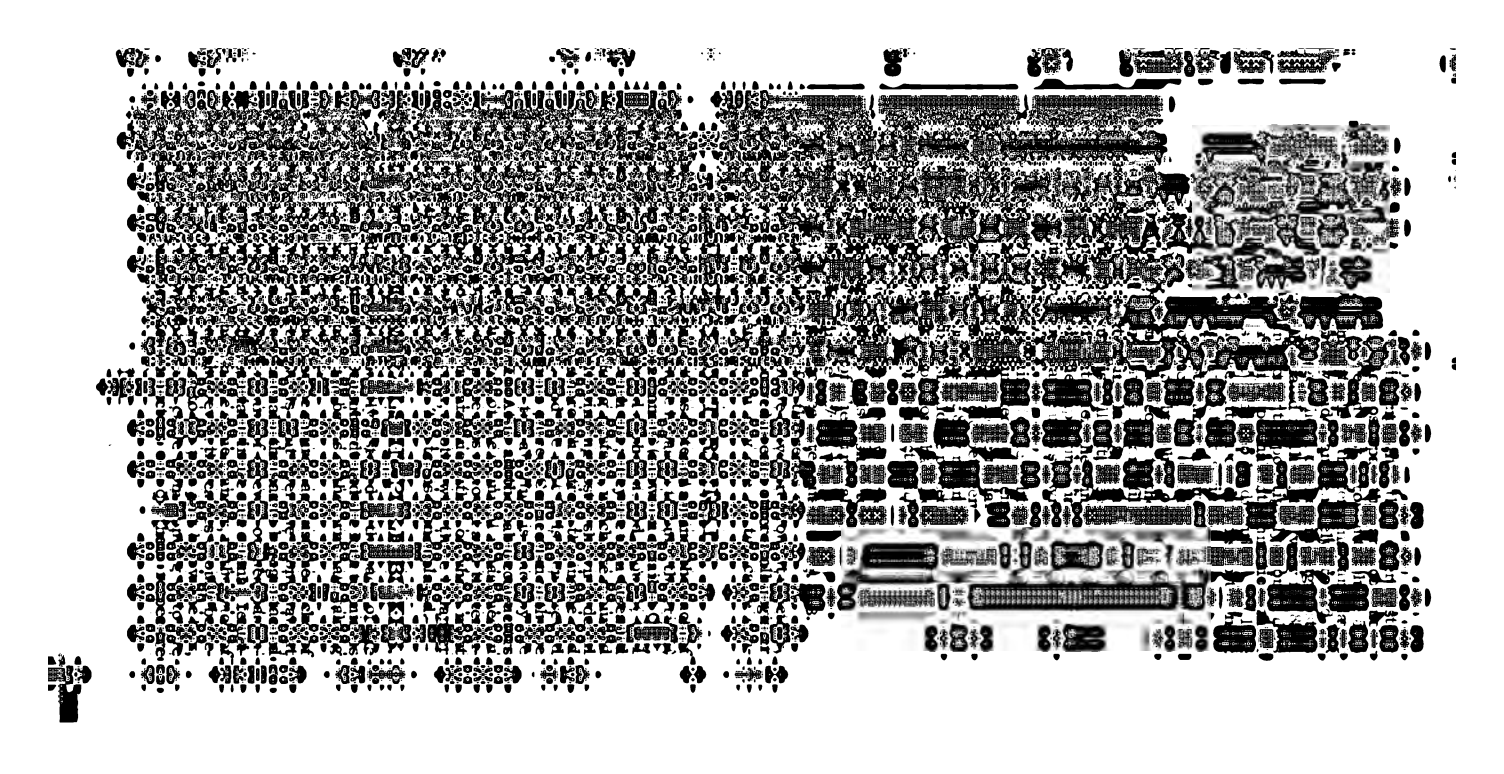
On account of the greater convenience of so doing, the cable ends are as far as possible prepared before insertion into the box, by removing the insulation the proper distance and scraping the wires bright in telephone or telegraph cables, and securely soldering the binding posts or heads to the conductors of electric light or power cables, (see T fig. 34 and J fig. 33). The distance of these posts or heads from the end of the lead cover must be carefully determined with reference to the position they are to occupy in the junction box. The cable ends are then passed through the end of the Conner junction box, or the nipple of the other style, until the lead cover is at least one inch within the outer end. A wiped solder joint is then made between the lead cover and the nipple or box, except in the Fowler junction box, where melted solder is poured into the enlarged inner end, O, of the nipple; but before doing this, the wire connection should be tried to make sure that the cable has been inserted the proper distance, and the connector of electric light and power cables should be put firmly in position between the two posts or heads of the box, to assure the best possible relation between the contact surfaces of the connectors and heads or posts, and kept so until the solder has become thoroughly set. When the cables have been soldered to the box, of either the Conner or Fowler class, examine all the connections again, and if found in proper condition, place the gasket in its place, and screw the cover down tight by means of the cover screws, being careful to bring them down gradually and all around the cover, that is, do not run one screw clear down to its limit before touching the others, but run each screw in turn half way down until you get around again to the first screw, then run it down a little further, and each of the others in turn the same distance, and so on, making three or four rounds, until all the screws are set to their limit; this will prevent springing the cover at any point, and will ensure even pressure on all parts of the gasket.

If it is a duplex cable, keep the connections spread apart as far as practicable, and tuck a sheet of pure gum tape in between them before putting on the cover, as a further safeguard against short circuiting.

In the other junction boxes (figs. 49 K, L, M, N), the conductors are brought to the binding posts or are spliced straight through as in making a regular cable joint, as the case may be, and the gaskets and covers are then put in position as above described. In the box shown in fig. 49 K, the hot compound should be poured through the hard rubber disc B, by removing the plug F, for that purpose. In figs. 49 L and 49 M, the wires which are spliced straight through can also be filled over with heated compound, but usually they are merely well taped, so as to be more easily accessible than they would be if the compartments were filled with compound. In the Fowler junction box, the hard rubber terminals are applied in the manner described under terminals, fig. 48, page 90. Unless the conductors go to binding posts or connectors which have numbers stamped on or alongside of them, they should be tagged with the same numbers as they bear at the terminals, thereby preventing the necessity of breaking a number of connections in search of a particular wire.

If placed directly in the ground between manholes or service boxes, it is best to build a rough wooden box around and over it, and fill the wooden box with pitch; also to mark the curb or building directly opposite the junction box to facilitate finding it subsequently if necessary. Employes should be especially cautioned to use the utmost care in replacing gaskets and covers after they have opened junction boxes for any purpose whatever, and the gaskets should be carefully examined at stated intervals, (not less than once every six months) and replaced with new ones if there are indications of inefficiency or decay.

If junction boxes are used on cables carrying extremely high potentials, say 5000 to 15000 volts or more, it is essential to make the insulation continuous, and as nearly as possible homogeneous, from the cable insulation of the incoming cable to that of the outgoing cable, because of the distance which currents of such high pressures will travel over surfaces of any kind, or spark through air.



TESTING ELECTRIC CABLES,

LOCATING FAULTS, Etc.

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The subject will be treated under four heads:

1st—ORDINARY OUTSIDE TESTING.

A common practice among telephone and electric light people has been to test underground wires with magneto bells and hand telephones. As the static charge of even a short length of underground cable is sufficient to ring a magneto bell and give a decided "click" from the telephone diaphragm, these instruments should never be absolutely relied upon for this purpose.

A small current-detector-galvanometer, such as may be bought for three or four dollars, with a few cells of battery, will always furnish practical evidence of the condition of underground wires, and its use is easily understood.

Before concluding that a cross, or ground, or open wire is in the outside cables, carefully examine and disconnect office cables, terminals, etc., and repeat the tests.

LEAKS OR GROUNDS. In testing for leaks or grounds, with the outfit above described, the cable wires should be opened at the point where they connect to the air lines and the test applied at the other end of the cable. One pole of the testing battery grounded, the other connected to one post of the galvanometer; a short piece of insulated wire attached to the other post of the galvanometer is then touched successively to the bared ends of the cable conductors, and any one causing a permanent deflection of the galvanometer needle, is faulty. A chloride of silver battery of at least 50 cells should be used for this purpose; horizontal galvanometers that will show a leak of over one megohm with 50 cells of battery can be purchased at Electrical Supply Stores. (See also page 140.)

CROSSES. In testing for crosses, bunch all the wires and connect them to one end of the testing circuit; then remove, one by one, the wires bunched, touching each successively to the other end of the testing circuit. (See also page 140). A sudden deflection of the galvanometer needle indicates that the wire touched is crossed with one of the bunched wires; care must be taken to see that none of the wires are in contact with each other or the lead cover at the other end of the cable.

IDENTIFYING WIRES WITHOUT CUTTING. It is frequently necessary to identify certain wires in a joint or cable, so that they may be brought out and connected to a subsidiary cable. (See pages 80, 81 and 129.) To do this, without cutting the wire or insulation, ground the desired wires at one end of the cable, being careful that all the other wires are separated and free from grounds at both ends; remove the lead from the joint or cable, and heat the insulated wires by a torch, furnace or hot insulating compound; as soon as the surplus insulation has been melted off, so that the individual wires can be separated, test for the grounded wires by means of a galvanometer and battery, as above described, making connection with each wire by means of

a needle or other sharp pointed instrument that can be used to pierce through the insulating covering.

CONTINUITY. To test for broken wires the conductors should all be grounded at one end and the test applied at the other end, as explained under "Leaks or Grounds" page 187; but in this case the deflection obtained from each wire is evidence that it is not broken.

2d—RESISTANCE AND CONDUCTIVITY OF WIRES.

RESISTANCE. The resistance of wires is most conveniently measured by means of a Wheatstone's Bridge, a three to six-cell battery and a Thompson Reflecting Galvanometer. Connections are made as in Figure 88, except that the battery wire S is connected to the juncture of l and R, instead of at g. Ordinarily the values of A and B may be 10, 100 or 1,000 ohms, and R may be varied from 1 to 10,000 ohms. Under these conditions

A=10 and B=1,000 for a resistance of 100 ohms or less;
A=100 and B=1,000 for a resistance of 100 to 1,000 ohms;
A=1,000 and B=1,000 for a resistance of 1,000 to 10,000 ohms;
A=1,000 and B=100 for a resistance of 10,000 to 100,000 ohms;
A=1,000 and B=10 for a resistance of 100,000 to 1,000,000 ohms.

Estimate the approximate resistance of the wire in question and choose the values of A and B; if the resistance cannot be even approximately estimated, commence with the first values of A and B above given, and if a value of R=10,000 gives a deflection in the same direction as when R=0, try successively the proportions above given till a balance of the needle is obtained.

Remove plugs from the resistance box until on pressing down the battery and galvanometer keys, no appreciable deflection of the needle is observable. If there is too much resistance in the box, the needle will swing one way, and if there is too little it will swing the other way. In testing long lines, or where extreme accuracy is not necessary, the resistance of the line will be $\frac{A}{B} \times$ resistance unplugged that gives the smallest deflection.

If an exact balance cannot be obtained, and great accuracy is desired, it will be necessary to note the deflections imparted to the needle when a variation of one ohm makes it move in opposite directions.

Let d = the deflection with a resistance of R′ ohms in the box; let d′ = the deflection with a resistance of R′ + 1 ohm in the box; then the correct resistance $R = R' + \frac{d}{d+d'}$ and the resistance of the wire, as measured, is $\frac{A}{B}R$

If lead wires are used instead of inserting the wire under test into the binding post of the Wheatstone Bridge, the resistance of the former must be measured and deducted from the total resistance.

Where no return wire is available, ground thoroughly the distant end of the conductor c (Fig. 88), and also ground l instead of connecting it to a; where very accurate results are desired in measuring lines of, say, 50 miles or more, the resistance of "earth" should be deducted from the total resistance.

CONDUCTIVITY. Measure carefully the resistance of the wire, as above described, and note its temperature, (usually the temperature of the surrounding air); then ascertain the correct length, and, where the size is not known, the diameter of the wire should be measured in several places with a Micrometer Gauge and the mean of these readings taken as the probable average diameter.

On page 161 will be found the resistance per 1000 feet of various sizes of pure copper wire, for a temperature of 68° F. In order to compare the resistance per 1000 feet at 68° F. of the wire in question, with pure copper wire, proceed as follows:

(a). Calculate what the resistance of the given wire will be at 68°. Letting R= the resistance of the wire as measured, R′= the resistance of the wire at 68° F, and t= the difference between the temperature of the wire and 68°.

Then for copper wire we have $R' = R(1+.0021\,t)$ where the temperature of the wire is less than 68° F; and $R' = \frac{R}{1+.0021\,t}$ where the temperature of the wire is greater than 68° F.

And for iron wire we have for the first case $R' = R(1+.0089\ t)$; and for the 2nd case $R' = \frac{R}{1+.0089\ t.}$

(b). Calculate the resistance per 1000 feet of the wire as follows: Divide the resistance at 68° F. by the number of feet and multiply the quotient by 1000. If the wire corresponds in size to one of the sizes on page 161 then the conductivity is found by dividing the resistance per 1000 feet, as given in the table for the size in question, by the corrected resistance of the wire per 1000 feet as previously calculated.

If the wire does not correspond to any size given in the table, proceed thus: Letting d= the diameter of the wire in mils, R= the ohms resistance per 1000 feet of a pure copper wire with diameter =d, and K= constant or 10,792.* Then $R = \frac{K}{d^2}$ and the conductivity is found by dividing R as thus calculated by the resistance of the given wire per 1000 feet at 68° F.

3rd—INSULATION AND CAPACITY TESTS.

The necessary electrical apparatus is: A Thomson Reflecting Galvanometer and its shunt, a 1-10 megohm resistance box, a condenser and discharging key, chloride of silver battery of not less than 50 cells (preferably 100) and an appropriate switch.

INSULATION TESTS. Having determined from what end of the cable the tests are to be made, secure the use of a room or basement (preferably the latter), in which to set up the instruments. Run two highly insulated wires to the end of the cable, and connect one to the lead cover and the other to the conductor whose insulation resistance is required, the remaining conductors, if any, being connected to the lead cover; set up the instruments on a large table and make the connections as illustrated in Figure 86, where *R* is the 1-10 megohm box, *G* the galvanometer, *F* its shunt, *B* the battery, and *S* a switch; insert the plug in the 1-999 shunt, place the switch *S* in the position represented by dotted lines and close the battery switch, *b*; now open the short-circuit key *c*, of the shunt, and read the deflection, which we will call d; then close the shunt key *c*, and place the switch *S*, in the position shown full in the figure; again open the shunt key, and if no deflection is observable, remove the plug from the 1-999 shunt, so that all the current can go through the galvanometer; then after about one minute's electrification, read the deflection, which we will call d'. The insulation resistance of the conductor expressed in megohms, is then $\frac{100 \times d}{d'}$. If a one megohm resistance box is used the numerator of this fraction becomes $1000 \times d$, but the 1-99 shunt will in general give the largest readable deflection, in which case the formula remains as given. The insulation resistance of the lead wires should be carefully measured, and if any deflection is observable, the value of d' must be diminished by the amount of this deflection.

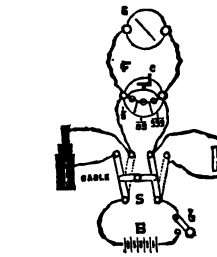


Fig. 86.

If in determining d' the spot of light goes off the scale it will be necessary to use the shunt that will give the largest readable deflection, and then d' is multiplied by 10 for the 1-9 shunt, by 100 for tne 1-99 shunt, and by 1000 for the 1-999 shunt. A large deflection, gradually increasing in value, generally indicates polarization, and, when this is the case, the lead of the cable has been broken or torn off through careless handling, or else the ends have been unprotected so as to admit the passage of moisture into the cable. One hundred cells of battery should be used.

To find the insulation resistance per mile, multiply the absolute insulation resistance by the length of the cable in miles. On page 158 is a table of "feet expressed in decimal of a mile," which can be used in this connection.

CAPACITY TESTS. The arrangement for making electro-

*Diameter^2 X resistance per 1000 feet.

static capacity tests is shown in Figure 87, where G is the galvanometer, F its shunt, A is the discharging key, S a switch, B the battery and D the battery switch.

Fig. 87.

As in the case of insulation resistance tests, connection should be made to one wire free from all the others, and to the others grounded to the lead of the cable. When the discharging key A is in repose we have electrical connection between a and b, and between d and e; press down firmly the buttons P P, to connect a to c and d to f; the condenser or the cable can thus be charged at will by means of the battery B, and the switch S; six cells are generally sufficient for ordinary testing. Place the switch, S, so as to charge the condenser, and if the spot of light goes off the scale with no shunt, put the plug in that shunt which will give the largest readable deflection; hold down firmly the buttons P P, for about 15 seconds, and then release them suddenly, noting the throw imparted to the needle; in like manner read the throw from the cable after it has been charged.

Where shunts are used, the throw must be multiplied by 10 for the 1-9 shunt, 100 for the 1-99 shunt and 1000 for the 1-999 shunt; letting t equal the effective throw of the condenser, t' equal the effective throw of the cable and K the capacity of the condenser in microfarads, then the capacity of the cable in microfarads equals $\frac{t' \times K}{t}$, and the capacity per mile is obtained by dividing this result by the length of the cable in miles.

Where great accuracy is required, it is best to have both throws as nearly equal as possible, by using a multiple series condenser and inserting such a capacity as will give a deflection about equal to that of the cable.

4th—LOCATING GROUNDS, LEAKS, CROSSES AND OPEN WIRES.

This subject is so broad and comprehensive that we will only be able to outline a few methods.

GROUNDS OR LEAKS, under 10,000 Ohms Resistance. For accurate work use the instruments mentioned under "Resistance," page 138.

When at least two good conductors, in addition to the "grounded wire," are accessible: Set up the instrument in the ordinary manner and run two lead wires of equal dimensions to the cable; measure carefully the resistance of these two wires, then measure in turn the combined resistance of the grounded wire and one of the good wires, the grounded wire and the other good wire, and the two good wires; these three wires must, of course, be connected at the distant end of the cable, then letting

l equal the resistance of each lead wire,
d equal the resistance of the grounded wire,
c equal the resistance of one good wire,
e equal the resistance of the other good wire,

and K, K′ and K″ equal the respective measured resistances, we have: $2l+d+c=K$; $2l+d+e=K'$; $2l+c+e=K''$; from which, by algebraic elimination, we get

$$d=\frac{K+K'-K''-2l}{2} \text{ and } c=\frac{K+K''-K'-2l}{2}.$$

Fig. 88.

By this means, therefore, we are enabled to know the exact resistance of the grounded wire, provided it be not grounded in more than one place.

Now make the connections shown in Figure 88; A and B are the arms of the bridge, R is the resistance in the box, l l the lead wires running to the cable, c is the good wire, a and b separate portions of the faulty wire grounded at g; G is the galvanometer. Ground one side of the battery, (preferably to the lead cover of the cable) and connect the other to the juncture of B and A, as shown in the diagram; remove plugs from the resistance box until, on pressing down the battery and galvanometer keys, no deflection of the galvanometer needle is observable; then letting the letters in Figure 88 stand for the resistance of the various parts, and, remember-

ing that d, the resistance of the grounded wire, as previously obtained, equals a+b, we have, by Wheatstone's law, A (a+l+R)=B (b+c+l); substituting for b its value, d—a, and reducing, $a=\frac{B(d+c+l)-A(l+R)}{A+B}$ We thus obtain the actual resistance to the ground, and letting D represent the total length of the grounded wire, we have as the distance to the ground, $\frac{a}{d}$D.

We recommend the following as a check method: Reverse the wires at the binding posts of the bridge, as shown in Figure 89; remove the plugs until a balance is obtained, then by Wheatstone's law we have, A (b+c+l+R) =B (a+l) and, reducing, $a=\frac{A(d+c+l+R)-Bl}{A+B}$ and, as before, the distance to the ground equals $\frac{a}{d}$D

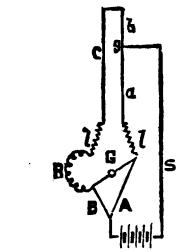


Fig. 89.

This ought to agree very closely with the value obtained by the previous method; care must be taken to see that the length taken for the grounded wire is correct, for this is often a source of error. Three or four cells of battery will be sufficient for ordinary use, but where a leak of several thousand ohms is to be located 50, or even 100, cells ought to be used in the last two methods. For ordinary testing A—10 and B—1,000 ohms.

Where only one good wire is accessible and this wire is of the same general dimensions as the grounded wire, the approximate resistance of the grounded wire can be found by taking half of the actual combined resistance of the two wires, after which proceed as has been indicated in the previous methods.

Where no good wire is accessible, the following method may be adopted, but it cannot be relied on unless the resistance of the ground is unvariable: Set up the instruments at one terminal of the cable; ground very thoroughly on the lead of the cable one of the wires running to the Wheatstone's Bridge; connect the other wire to the grounded conductor and measure the resistance of the circuit; then proceed to the other terminal of the cable and in like manner measure the resistance of the circuit from that end; then, letting a= the resistance to the ground from one end, b= the resistance from the other end, R and R′= the respective measured resistances, and letting R″= the resistance of the grounded wire, (which can be calculated by knowing its length and size), we have $a=\frac{R+R''-R'}{2}$ and $b=\frac{R'+R''-R}{2}$ and the distance to the ground from the end where the first measurement was made $=\frac{a}{R''}$D

If the resistance of the ground is variable, it will, in general, be indicated by the difficulty to obtain a balance with the Wheatstone's Bridge and by a non-accordance of the resistance as measured with the battery reversed.

CROSSES of variable or unvariable resistance where two good wires, in addition to the crossed wires, are accessible:

If each crossed wire cannot be identified separately at the terminals of the cable the following method will, in general, make identification certain: Number the crossed wires at the testing end of the cable, No. 1 and No. 2, and at the far end No. 3 and No. 4 respectively; call the good wire No. 5; make the following four sets of connections and measure the respective resistances.

(a) Wires from Wheatstone's Bridge to No. 5 and No. 1, with No. 5 and No. 3 connected at far end of cable. (b) Wires from Wheatstone's Bridge to No 5 and No. 1, with No. 5 and No. 4 connected at far end of cable. (c) Wires from Wheatstone's Bridge to No. 5 and No. 2, with No. 5 and No. 4 connected at far end of cable. (d) Wires from Wheatstone's Bridge to No. 5 and No. 2, with No. 5 and No. 3 connected at the far end of cable.

Let R′ R″ R‴ R⁗ stand for measured resistance; if R′+R‴ is less than R″+R⁗ then No. 1 and No. 3 are one wire, No. 2 and No. 4 the other wire, while, if R′+R‴ is greater than R″+R″′, No. 1 and No. 4 are one wire and No. 2 and No. 3 the other; if the resistance of the cross is constant its value is one-half the difference between R′+R‴ and R″+R⁗. After finding

the separate resistance of one of the crossed wires and the good wire by the method given in the previous heading, proceed exactly as directed in the methods for **locating grounds**, except that, instead of grounding the battery, connect it to the wire that is crossed with the one used in making the test. In Figures 88 and 89 the ground wire *S* may be considered as the wire crossed with a+b and then it is evident that the formulæ derived from these figures for grounded wires are applicable to crossed wires also.

Where a single wire is crossed or grounded in more than one place, or where there are many crosses or grounds in one cable of several conductors, complications occur that often defy solution. The conditions of the case in hand might be such that the fault could be located approximately by specially devised methods; fortunately in practice such a state of affairs seldom occurs. In order to facilitate such tests as are above described, orders as to the connections to be made should be given by means of a telephone or telegraph instrument to a person stationed at the far end of the cable.

OPEN WIRES. **Where one good wire is accessible,** set up the instruments as shown in Fig. 87; take a throw first on the open wire, then on the good wire and finally on the good wire connected to the open wire at the far end of the cable; letting t, t′ and t″ equal the respective throws, and letting D equal the total length of the broken wire, the distance to the break is $\frac{t}{t''-t'+t}D$.

It is usually best to make insulation resistance test of the broken wire before proceeding as above: also measure the resistance of the break by connecting one wire to the broken conductor at the near end of the cable and the other wire to the good conductor connected to the broken wire at the far end of the cable; if the resistance in either case is much less than one megohm the results obtained cannot be thoroughly relied upon.

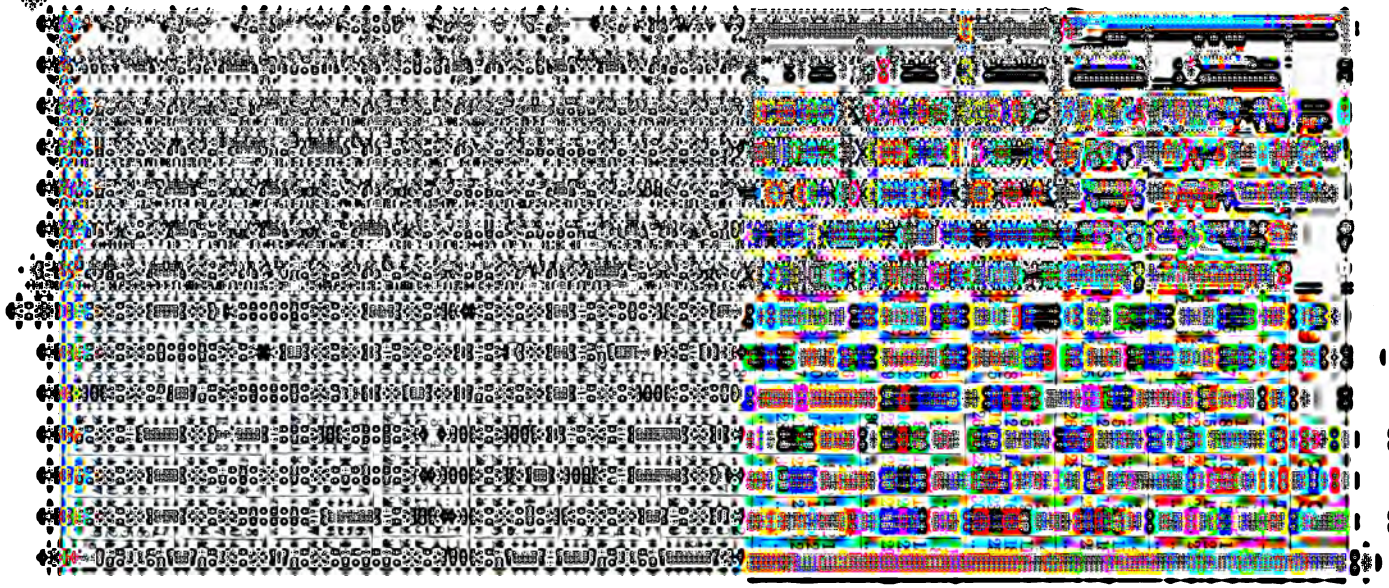
Where no good wire is accessible, proceed as follows: Set up the instruments at one end of the cable, and take a throw on the open wire and on the condenser, then go to the other end of the cable and take similar throws there; letting t and t′ equal the first and second throws on the cable and c and c′ the corresponding condenser throws, we have as the distance to the break from the end where the first test was made $\frac{t \times D}{\frac{c}{c'}t'+t}$

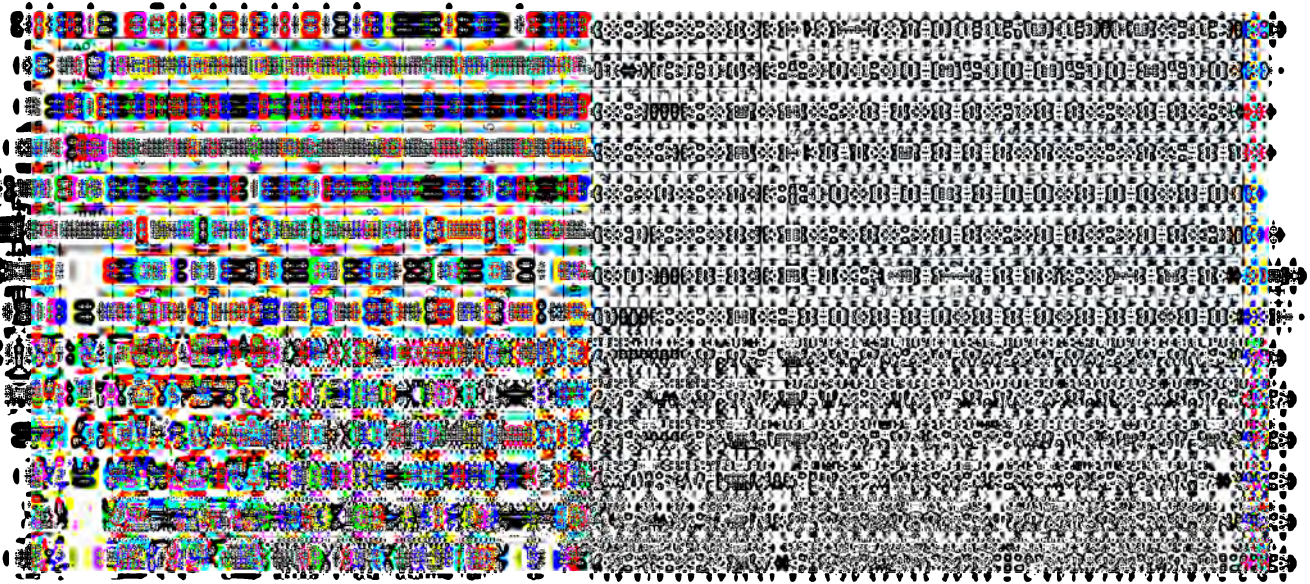
As stated before, the insulation resistance of the broken wire, as well as the resistance of the break, should be measured. If the insulation resistance of the open wire is high, the resistance of the break can be found by grounding the open wire at the far end of the cable, and connecting one lead wire to ground and the other to the open wire at the testing end of the cable.

GENERAL

AND

ELECTRICAL INFORMATION.





POSTAL GUIDE.

Compiled from U. S. Official Postal Guide, for Dec. 1896.

DOMESTIC MAIL.

FIRST CLASS.

Letters, postal cards and matter wholly or partly in writing, whether sealed or unsealed (except manuscript accompanying proof sheets or corrected proof sheets of the same), and all matter sealed or otherwise closed against easy inspection.

Rate of Postage.—Letters, two cents per ounce or fraction thereof; postal cards, one cent each; on "drop" letters, two cents per ounce or fraction thereof when mailed at letter carrier office, and one cent per ounce or fraction thereof at other offices.

SECOND CLASS.

Only for publishers and news agents, and applying to newspapers and publications issued at stated intervals, as often as four times a year; must not be designed primarily for advertising purposes, or for free circulation at nominal rates.

Rate of Postage.—One cent per pound or fraction thereof, when sent by publisher from office of publication, or when sent from news agency to actual subscribers or other news agents.

On newspapers and periodical publications of this class, when sent by other than publisher or news agent, one cent for each four ounces or fraction thereof.

Publications of second class, one copy to each actual subscriber residing in county where same are printed in whole or in part and published, but not to be delivered at letter carrier offices or by carriers, free.

Printed or written name and address of publisher or sender, but without advertisement, may be placed on second class matter.

THIRD CLASS.

Books, periodicals, photographs and matter wholly in print, (not included in second class) proof sheets, corrected proof sheets and manuscript copy accompanying the same.

By printed matter under this class is meant: "The reproduction upon paper, by any process except that of hand writing, or any words, letters, characters, figures or images, or of any combination thereof, not having the character of an actual and personal correspondence;" it also includes circulars, designed to be, "A printed letter, which, according to internal evidence, is being sent in identical terms to several persons. It is permissible to write in circulars the date, the name of the person addressed, or of the sender, and to correct mere typographical errors." The name, address and advertisement of the sender may be placed on third class matter.

Rate of Postage.—One cent for each two ounces or fraction thereof.

FOURTH CLASS.

Merchandise, namely, all matter not embraced in the other three classes, and which is not, in its form or nature, liable to destroy, deface, or otherwise damage the contents of the mail bag, or harm the person of any one engaged in the postal service and not above the weight provided by law.

Rate of Postage.—One cent per ounce or fraction thereof, but on seeds, cuttings, roots, scions and plants, one cent for each two ounces or fraction thereof.

MONEY ORDERS.

Orders not exceeding	$2.50, 3 cents.
Over $2.50 and not exceeding	5.00, 5 cents.
Over 5.00 and not exceeding	10.00, 8 cents.
Over 10.00 and not exceeding	20.00, 10 cents.
Over 20.00 and not exceeding	30.00, 12 cents.
Over 30.00 and not exceeding	40.00, 15 cents.
Over 40.00 and not exceeding	50.00, 18 cents.
Over 50.00 and not exceeding	60.00, 20 cents.
Over 60.00 and not exceeding	75.00, 25 cents.
Over 75.00 and not exceeding	100.00, 30 cents.

When a larger sum than $100.00 is required, additional orders must be obtained to make it up, and no more than three domestic orders may be issued in one day to the same remitter in favor of the same payee, payable at the same post office.

SPECIAL DELIVERY.

Special immediate delivery by messengers may be secured for postal matter of any class, at any postoffice, by affixing, in addition to the regular postage, a special delivery stamp, which can be bought at any postoffice.

REGISTRATION.

[Domestic or Foreign Mail.]

Any letter or parcel may be registered upon affixing thereto 8 cents in postage stamps in addition to the stamps that would be required for the same article if not registered.

FOREIGN MAIL.

The following are the rates of postage to all countries and colonies (except Canada and Mexico) comprising the *Universal Postal Union*, among which are all European and South American countries and colonies, Asiatic Turkey, most of the West Indies, British India, Ceylon, Congo, Egypt, Algeria, Greenland, Hawaii, the following post offices in China: Hong Kong, Kiung Chow, Canton, Swatow, Amoy, Shanghai; and Fusam-po, Genzanshin and Jinsen (Corea); also Labuan, Liberia, Mauritius, Persia, Siam and Tunis, viz:

Letters, per 15 grams (½ ounce) 5 cents; Postal Cards, each 2 cents; Newspapers and other printed matter per 2 ounces, 1 cent.

Commercial Papers: { Packets not in excess of 10 ounces, 5 cents. Packets in excess of 10 ounces for each two ounces or fraction thereof, 1 cent.

Samples of Merchandise: { Packets not in excess of 4 ounces, 2 cents. Packets in excess of 4 ounces, for each 2 ounces or fraction thereof, 1 cent.

Australia via San Francisco (except New South Wales, Queensland and Victoria, which take same rate as "via Brindisi"), letters, 5 cents each half ounce or fraction; newspapers, 2 cents per copy; other matter, 2 cents for each two ounces or fraction.

Australia, British mail *via Brindisi:* letters, 12 cents each half ounce or fraction; newspapers, 2 cents per copy; other matter, four cents for each four ounces or fraction.

China, British mail *via Brindisi:* letters, 13 cents each half ounce or fraction; newspapers, 5 cents for each four ounces or fraction; other matter, 4 cents each two ounces or fraction,

Chatham Islands via San Francisco, *New Zealand*, *Norfolk Islands* and *Tasmania*, same as Australia, via Brindisi.

Where 2 cent postal cards cannot be obtained, use a U. S. one cent card with a one cent U. S. postage stamp affixed.

Ordinary letters for countries of the Postal Union, (except Canada and Mexico) must be forwarded, whether any postage is prepaid on them or not. All other mailable matter must be prepaid at least partially.

PARCELS POST.

Foreign Parcels Post conventions have lately been concluded between the United States and Jamaica, British Honduras, Bahama Islands, Leeward Islands, Barbadoes, the Hawaiian Kingdom, and the Republic of Costa Rica.

Packages of merchandise other than samples, and all other articles not prohibited, may be forwarded to any of these countries at the following rates of postage, which must in every case be prepaid.

For a parcel not exceeding 1 pound in weight, 12 cents.

For every additional pound or fraction thereof, 12 cents.

The dimensions allowed are:

Greatest length, 3 feet, 6 inches. Greatest length and girth combined, 6 feet. The maximum weight, 11 pounds.

CANADA AND MEXICO.

Matter mailed in the United States addressed to CANADA or MEXICO, is subject to the same postage rates and conditions as it would be if it were addressed for delivery in the United States, except that "Commercial Papers" are transmissible at the rate given above opposite "Commercial Papers," and that for MEXICO all articles of miscellaneous merchandise (fourth-class matter) not sent as bona fide trade samples, are required to be sent by "Parcels Post" at the rate given above opposite "Samples of Merchandise."

The following articles are absolutely EXCLUDED from the mails (CANADA or MEXICO) without regard to the amount of postage prepaid or the manner in which they are wrapped, namely: All sealed packages other than letters in their usual and ordinary form; publications which violate any copyright law of either country respectively; also (MEXICO) liquids, pastes, confections and fatty substances, and all packages except such as are sent by "Parcels Post:" and (CANADA) all packages (except single volumes of printed books and packages of second class matter) which weigh more than four pounds six ounces, and "Police Gazettes."

Single volumes of printed books, in unsealed packages (without limit as to weight), are transmissible to MEXICO in the regular mails.

GENERAL REGULATIONS.

Applying to Domestic Mails and Foreign Mails except as modified under the head of "Foreign Mails."

LIMIT OF WEIGHT.

Four pounds, unless it be a single book. This limitation does not apply to second-class matter mailed in packages at the pound rate. If package contains liquids, the limit is four ounces, liquid measure.

PAYMENT OF POSTAGE.

On first-class matter the postage should be fully prepaid, but if two cents in stamps be affixed, the matter will be forwarded and remainder due collected of addressee before delivery.

On second, third and fourth class matter, the postage must be fully prepaid.

POSTAGE DUE.

When two cents has been paid on first class matter, the remainder is collected on delivery at single rates. When matter reaches, by inadvertence, the office of destination without any prepayment, postage is collected at double the prepaid rates.

UNMAILABLE MATTER.

Anything held for postage, misdirected, destructive, scurrilous matter, obscene matter, lottery matter, packages of domestic third and fourth class matter weighing over four pounds (except single books and official matter eminating from the Departments at Washington) and of foreign matter in excess of weight or size fixed by stipulation of postal treaty.

Coin, Jewelry and other precious articles are prohited by postal treaty from being sent in the mails to foreign countries.

Forwarding and Returning Mail Matter.

Letters or parcels prepaid at letter rates will be forwarded from one post office to another upon the written request of the person addressed, without payment of additional postage; other mail matter must be charged with additional postage at original rate.

Letters or parcels prepaid at letter rates, bearing written or printed return card, will be returned to writer at the time he may direct; or after remaining uncalled for thirty days; postal cards will also be returned after thirty days if they disclose name and address of writer and are wholly or partly written, other matter must pay additional postage if to be returned.

*Deeds, Bonds, Receipts, Bills of Lading, etc., or any writing that is not a personal communication.

STATES AND TERRITORIES OF THE UNITED STATES.

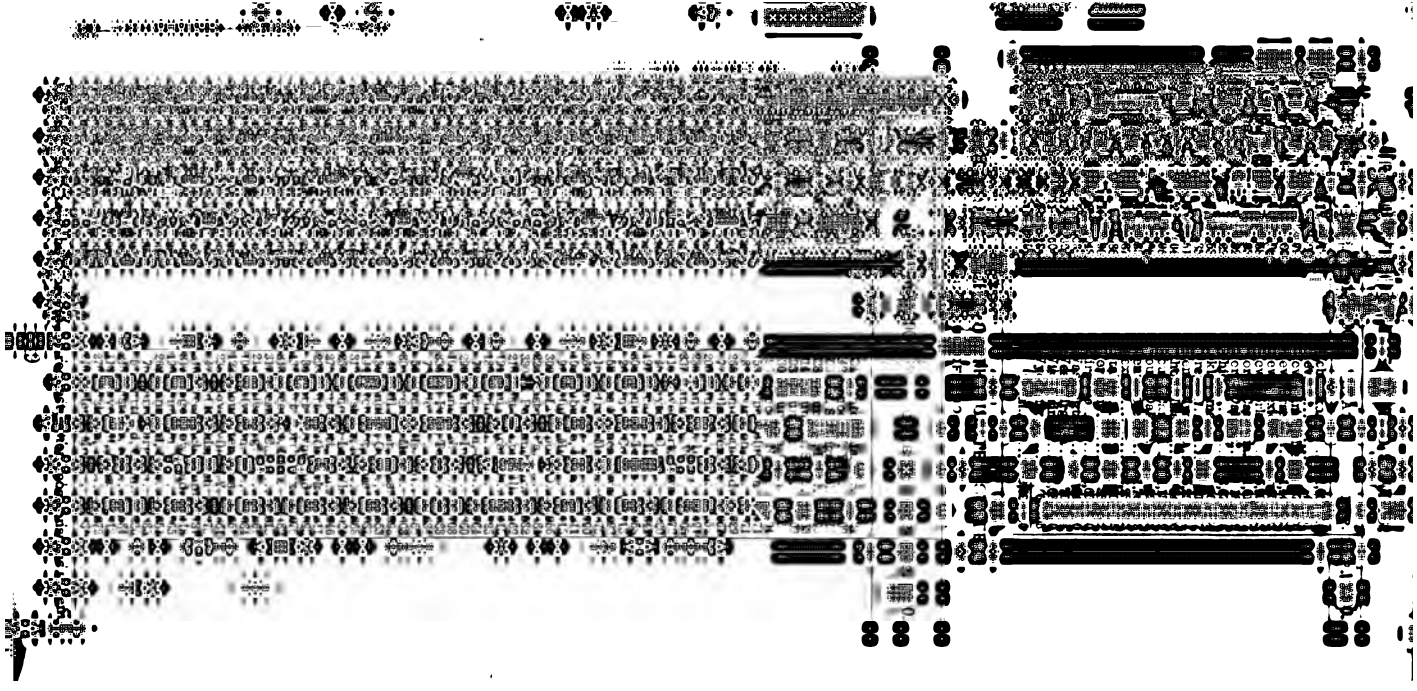
States and Territories.	Area in Sq. Miles.	Population.		Order According to Population.		Electoral Vote.*		Number of Members of Congress.
		1890	†1900	1890	†1900	1896	†1900	
Alabama	51,540	1,513,017	.....	17	.....	11 D	.....	9
Arizona	112,920	59,620	.....	48	.....	.....	.....	.....
Arkansas	53,045	1,128,179	.....	24	.....	8 D	.....	6
California	155,980	1,208,130	.....	22	.....	8R 1D	.....	7
Colorado	103,645	412,198	.....	31	.....	4 D	.....	2
Connecticut	4,845	746,258	.....	29	.....	6 R	.....	4
N Dakota... }	147,700	182,719	.....	41	.....	3 R	.....	1
S. Dakota.... }		328,808	.....	37	.....	4 D	.....	2
Delaware	1,960	168,493	.....	42	.....	3 R	.....	1
Dist. of Col	60	230,392	.....	39	.....	.....	.....	.....
Florida	54,240	391,422	.....	32	.....	4 D	.....	2
Georgia	58,980	1,837,353	.....	12	.....	13 D	.....	11
Idaho	84,290	84,385	.....	45	.....	3 D	.....	1
Illinois	56,000	3,826,351	.....	8	.....	24 R	.....	22
Indiana	35,910	2,192,404	.....	8	.....	15 R	.....	13
Iowa	55,475	1,911,896	.....	10	.....	13 R	.....	11
Kansas	81,700	1,427,096	.....	19	.....	10 D	.....	8
Kentucky	40,000	1,858,635	.....	11	.....	12 R 1 D	.....	11
Louisiana	45,420	1,118,587	.....	25	.....	8 D	.....	6
Maine	29,895	661,086	.....	30	.....	6 R	.....	4
Maryland	9,860	1,042,390	.....	27	.....	8 R	.....	6
Massachusetts	8,040	2,238,943	.....	6	.....	15 R	.....	13
Michigan	57,430	2,093,889	.....	9	.....	14 R	.....	12
Minnesota	79,205	1,301,826	.....	20	.....	9 R	.....	7
Mississippi	46,340	1,289,600	.....	21	.....	9 D	.....	7
Missouri	68,735	2,679,184	.....	5	.....	17 D	.....	15
Montana	145,310	182,159	.....	44	.....	3 D	.....	1
Nebraska	76,185	1,058,910	.....	26	.....	8 D	.....	6
Nevada	109,740	45 761	.....	49	.....	3 D	.....	1
New Hamp	9,005	376,530	.....	33	.....	4 R	.....	2
New Jersey	7,465	1,444,933	.....	18	.....	10 R	.....	8
New Mexico	122,460	158 593	.....	43	.....	.....	.....	.....
New York	47,620	5,997,853	.....	1	.....	36 R	.....	34
N. Carolina	48,580	1,617,947	.....	16	.....	11 D	.....	9
Ohio	40,760	3,672,316	.....	4	.....	23 R	.....	21
Oregon	94,560	313,767	.....	38	.....	4 R	.....	2
Pennsylvania	44,985	5,258,014	.....	2	.....	32 R	.....	30
Rhode Island	1,058	345,506	.....	35	.....	4 R	.....	2
S. Carolina	30,170	1,151,149	.....	23	.....	9 D	.....	7
Tennessee	41 750	1,767,518	.....	13	.....	12 D	.....	10
Texas	262,290	2,235,523	.....	7	.....	15 D	.....	13
Utah	82,190	207,905	.....	40	.....	3 D	.....	1
Vermont	9 135	332,422	.....	36	.....	4 R	.....	2
Virginia	40,125	1,655,980	.....	15	.....	12 R	.....	10
Washington	66,880	349,390	.....	34	.....	4 D	.....	2
W. Virginia	24,645	762,794	.....	28	.....	6 R	.....	4
Wisconsin	54,450	1,686,880	.....	14	.....	12 R	.....	10
Wyoming	97,575	60,705	.....	47	.....	3 D	.....	1

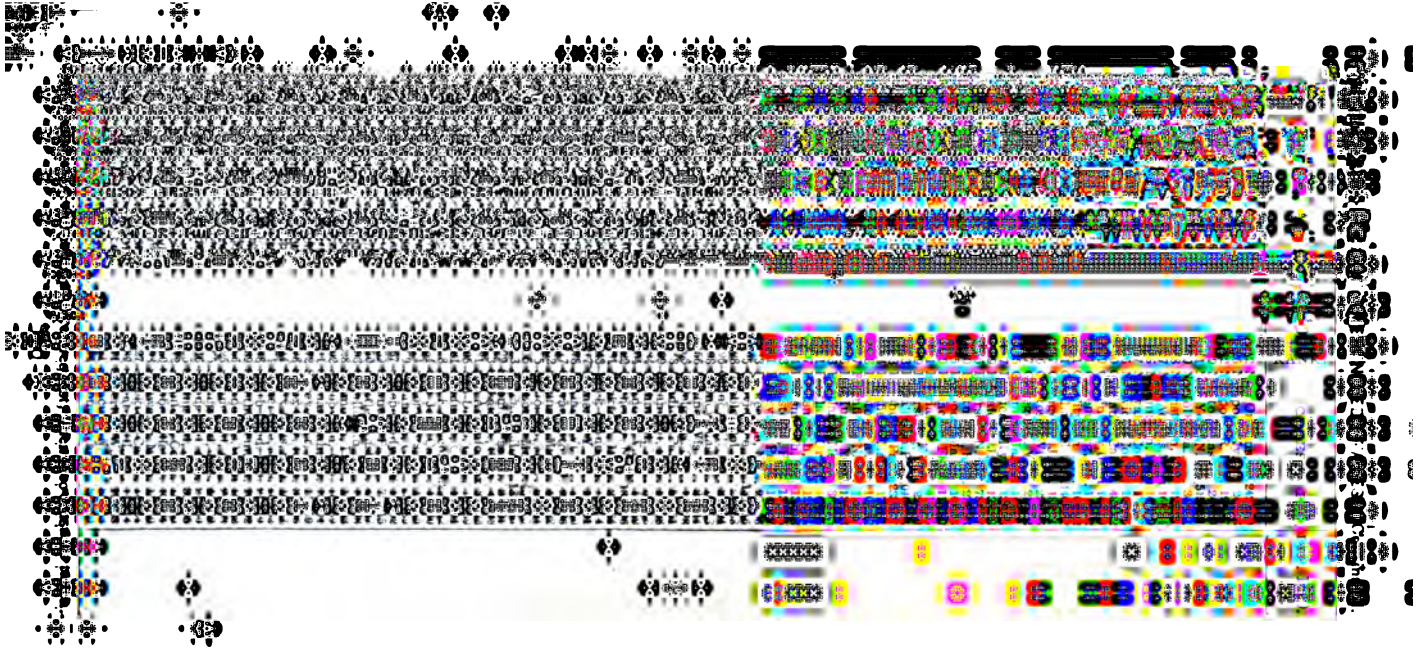
*D, Democrat, R, Republican, in Presidential election of year named.
The States whose electoral vote is printed in *italics* have been admitted since the Presidential election of 1892.
†Printed pasters will be supplied by us for these three columns, upon request, as soon as officially determined.

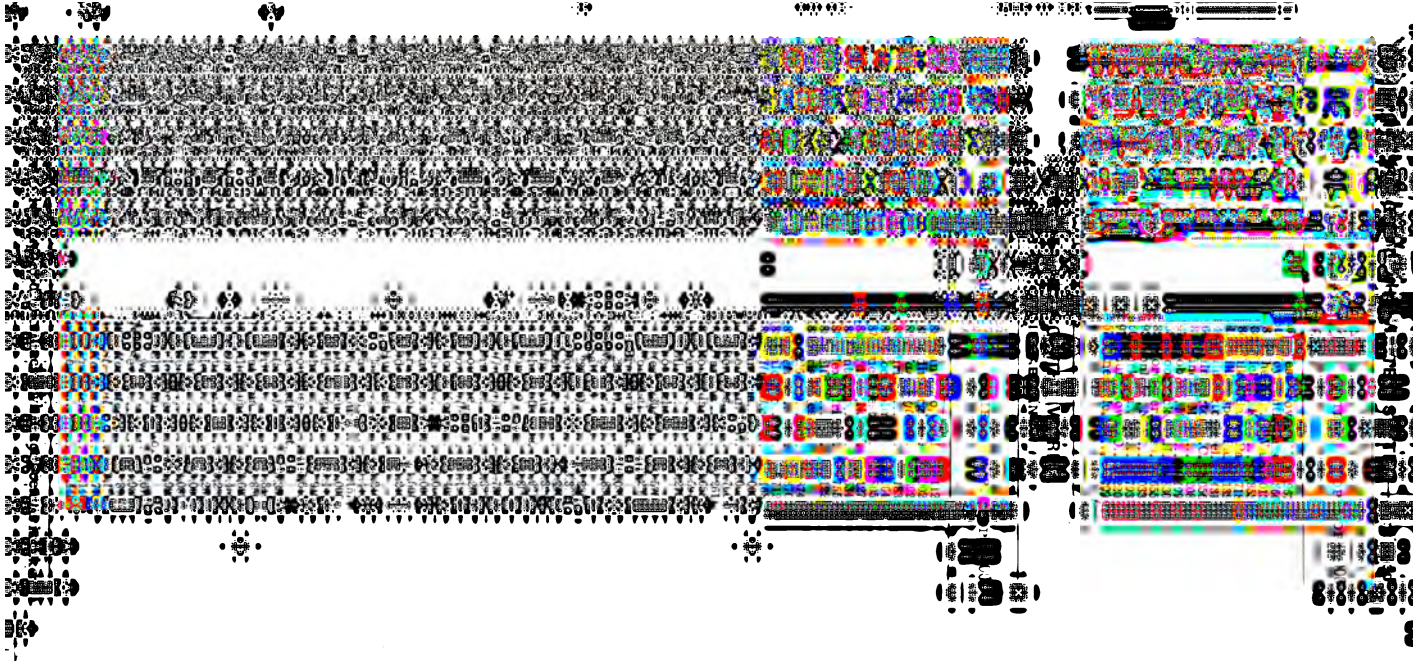
CONGRESS FROM 1870.

The political attitude of the two branches of Congress from 1870 to the present time is given below:

	SENATE.			HOUSE.		
	R.	D.	Ind.	R.	D.	Ind.
1870	57	17	.....	138	108	.....
1872	45	10	.....	199	88	.....
1874	44	29	.....	114	176	.....
1876	40	36	.....	140	153	.....
1878	34	42	.....	135	158	.....
1880	38	37	1	147	135	11
1882	38	36	2	118	196	9
1884	42	34	.....	140	183	2
1886	39	37	.....	152	169	4
1888	45	37	.....	169	161	.....
1890	47	39	2	88	235	9
1892	37	44	4	127	218	11
1894	46	37	4	245	104	7
1896	...	...	.....	204	124	28







FRACTIONS OF AN INCH EXPRESSED IN MILS.

(Thousandths).

Numerator.	Sixty-Fourths.	Thirty-seconds.	Sixteenths.	Eighths	Fourths	Half.
1	15.625	31.25	62.5	125.	250.	500.
3	46.875	93.75	187.5	375.	750.	.....
5	78.125	156.25	312.5	625.	.....	.....
7	109.375	218.75	437.5	875.	.....	.....
9	140.625	281.25	562.5	.....	.....	.....
11	171.875	343.75	687.5	.....	.....	.....
13	203.125	406.25	812.5	.....	.....	.....
15	234.375	468.75	937.5	.....	.....	.....
17	265.625	531.25	.....	.....	.....	.....
19	296.875	593.75	.....	.....	.....	.....
21	328.125	656.25	.....	.....	.....	.....
23	359.375	718.75	.....	.....	.....	.....
25	390.625	781.25	.....	.....	.....	.....
27	421.875	843.75	.....	.....	.....	.....
29	453.125	906.25	.....	.....	.....	.....
31	484.375	968.75	.....	.....	.....	.....
33	515.625					
35	546.875					
37	578.125					
39	609.375					
41	640.625					
43	671.875					
45	703.125					
47	734.375					
49	765.625					
51	796.875					
53	828.125					
55	859.375					
57	890.625					
59	921.875					
61	953.125					
63	984.375					
.....	.....					
.....	.....					
.....	.....					
.....	.....					

Feet Expressed in Decimal Parts of a Mile.

	Units.	10s.	100s.	1,000s.
1	.000189	.001893	.01893	.1893
2	.000378	.003787	.03787	.3787
3	.000568	.005681	.05681	.5681
4	.000757	.007574	.07574	.7574
5	.000946	.009468	.09468	.9468
6	.001136	.011362	.11362	.....
7	.001325	.013255	.13255	.....
8	.001514	.015148	.15148	.....
9	.001704	.017042	.17042	.....

Example: Express 4,397 feet in decimal of a mile.

4,000 feet = .7574

300 " = .05681

90 " = .017042

7 " = .0013255

Total, .8325775 of a mile.

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Table of Squares, Cubes, Square Roots, and Reciprocals.

Numbers.	Squares.	Cubes.	Square Roots.	Reciprocals.
1	1	1	1.000	1.0000
2	4	8	1.414	0.5000
3	9	27	1.732	0.3333
4	16	64	2.000	0.2500
5	25	125	2.236	0.2000
6	36	216	2.449	0.1667
7	49	343	2.646	0.1429
8	64	512	2.828	0 1250
9	81	729	3.000	0.1111
10	100	1 000	3.162	0.1000
11	121	1 331	3.317	0.0909
12	144	1 728	3.464	0.0833
13	169	2 197	3.606	0.0769
14	196	2 744	3.742	0.0714
15	225	3 375	3.873	0.0667
16	256	4 096	4.000	0.0625
17	289	4 913	4.123	0.0588
18	324	5 832	4.243	0.0556
19	361	6 859	4.359	0.0526
20	400	8 000	4.472	0.0500
21	441	9 261	4.583	0.0476
22	484	10 648	4.690	0.0455
23	529	12 167	4.796	0.0435
24	576	13 824	4.899	0.0417
25	625	15 625	5.000	0.0400
26	676	17 576	5.099	0.0385
27	729	19 683	5.196	0.0370
28	784	21 952	5.292	0.0357
29	841	24 389	5.385	0 0345
30	900	27 000	5.477	0.0333
31	961	29 791	5.568	0.0323
32	1 024	32 768	5.657	0.0313
33	1 089	35 937	5.745	0.0303
34	1 156	39 304	5.831	0.0294
35	1 225	42 875	5.916	0.0286
36	1 296	46 656	6.000	0.0278
37	1 369	50 653	6.083	0.0270
38	1 444	54 872	6.164	0.0263
39	1 521	59 319	6.245	0.0256
40	1 600	64 000	6.325	0.0250
41	1 681	68 921	6.403	0 0244
42	1 764	74 088	6.481	0.0238
43	1 849	79 507	6.557	0.0233
44	1 936	85 184	6.633	0.0227
45	2 025	91 125	6.708	0.0222
46	2 116	97 336	6.782	0.0217
47	2 209	103 823	6.856	0.0213
48	2 304	110 592	6.928	0.0208
49	2 401	117 649	7.000	0.0204
50	2 500	125 000	7.071	0.0200
51	2 601	132 651	7.141	0.0196
52	2 704	140 608	7.211	0.0192
53	2 809	148 877	7.280	0.0189
54	2 916	157 464	7.348	0.0185
55	3 025	166 375	7.416	0.0182
56	3 136	175 616	7.483	0.0179
57	3 249	185 193	7.550	0.0175
58	3 364	195 112	7.616	0.0172
59	3 481	205 379	7.681	0.0169
60	3 600	216 000	7.746	0.0167
61	3 721	226 981	7.810	0.0164
62	3 844	238 328	7.874	0.0161
63	3 969	250 047	7.937	0.0159
64	4 096	262 144	8.000	0.0156
65	4 225	274 625	8.062	0.0154
66	4 356	287 496	8.124	0.0152
67	4 489	300 763	8.185	0.0149
68	4 624	314 432	8.246	0.0147
69	4 761	328 509	8.307	0.0145
70	4 900	343 000	8.367	0.0143
71	5 041	357 911	8.426	0.0141
72	5 184	373 248	8.485	0.0139
73	5 329	389 017	8.544	0.0137
74	5 476	405 224	8.602	0.0135
75	5 625	421 875	8.660	0.0133

TABLE OF WEIGHTS, MEASURES, ETC.

Copyright, 1890, by J. W. Marsh.

METRIC UNITS.	Constant.	United States Units.	No. of U. S. Units equal to 1 of the denomination next mentioned.
Area.			
1 Square Millimeter	.00155	Square inch	144
1 " Meter	10.763	" feet	43,560
1 Are (100 sq. meters)	.02471	Acre	640
1 Square Kilometer	.38612	Square mile	
Capacity.			
1 Liter	61.017	Cubic inches	
	.908	Quarts, dry	
	1.0566	" liquid	
1 Hectoliter	3.5315	Cubic feet	
	26.42	Gallons, liquid	
Lengths. (See General Table below.)			
1 Mil	.001	Inch	
1 Millimeter	.03937	"	
1 Centimeter	.3937	"	
1 Meter	39.37	Inches	12
	3.2809	Feet	3
	1 1-11	Yards	1760
1 Kilometer	.6214	Mile	
	3280.9	Feet	
Power.			
1 Kilogrammeter-sec	.01315	Horse Power	
NOTE:—			
1 ft. lb. per sec.	.001818	" "	
550 " " " "	1.	" "	
1 horse power	746.	Watts	
Temperature.			
1 Degree Centigrade	1.8°	Fahrenheit	
Zero.	32°	"	
Volume.			
1 Cubic Centimeter	.0610	Cubic inch	1728
1 Cubic Meter	35.3105	" feet	9
	1.3078	" yards	
Weights.			
1 Milogram	.01532	Grains	
1 Gram	15.432	"	7000
1 Kilogram	2.2047	Pounds, Avoir.	2000
1 Ton	1.1023	Tons (short)	
	.9842	Tons (long)	
Work.			
1 Kilogrammeter	7.2331	Foot pounds	
1 Centimeter Gram	.0007233	" "	
GENERAL TABLE.			
1 Fathom	2	Yards	
	6	Feet	6087
1 League	3	Nautical miles	
			No. of units of first column, same line, equal to one of next denomination.
1 Link	7.92	Inches	100
1 Chain	66	Feet	80
1 Mile	5280	Feet	
1 Rod, Perch or Pole	16.5	Feet	40
1 Furlong	220	Yards	8
1 Mile	1760	Yards	

RULE.—To reduce to opposite units, multiply amounts in units of the first column, or divide amounts in units of the third column by Constant (second column.)

NOTE.—Add 32 after multiplication, or subtract 32 before division in applying the foregoing rule to temperature reductions.

VALUES OF FOREIGN COINS.

FIXED BY U. S. TREASURY, APRIL 1, 1896.

COUNTRY.	Standard.	Monetary Unit.	Value in terms of U.S. gold dollar.
Argentine Republic	G & S	Peso	$0.96,5
Austria-Hungary	Gold.	Crown	.20,3
Belgium	G & S	Franc	.19,3
Bolivia	Silver	Boliviano	.49.3
Brazil	Gold.	Milreis	.54,6
British Possessions N. A. (except Newfoundland.)	Gold.	Dollar	1.00,0
Central Amer. States: Costa Rica, Guatemala, Honduras, Nicaragua, Salvador	Silver	Peso	.49,3
Chili	G & S	Peso	.91,2
China	Silver	Tael. Shanghai	.22,9
		Haikwan	.81,2
		(Customs)	.49,3
Columbia	Silver	Peso	.92,6
Cuba	G & S	Peso	.26,8
Denmark	Gold.	Crown	.23,8
Ecuador	Silver	Sucre	.49,3
Egypt	Gold.	Pound(100 piast's	4.94,3
Finland	Gold.	Mark	.19,3
France	G & S	Franc	.19,3
German Empire	Gold.	Mark	.23,8
Great Britain	Gold.	Pound (sterling).	4.86 6⅓
Greece	G & S	Drachma	.19,3
Hayti	G & S	Gourde	.96,5
India	Silver	Rupee	.23,4
Italy	G & S	Lira	.19,3
Japan	G & S	Yen	.99,7
			.53,2
Liberia	Gold.	Dollar	1.00,0
Mexico	Silver	Dollar	.53,6
Netherlands	G & S	Florin	.40,2
Newfoundland	Gold.	Dollar	1.01,4
Norway	Gold.	Crown	.25,8
Persia	Silver	Kran	.09,1
Peru	Silver	Sol	.49,3
Portugal	Gold.	Milreis	1.08,0
Russia	Silver	Ruble	.77,2
			.89,5
Spain	G & S	Peseta	.19,3
Sweden	Gold.	Crown	.26,8
Switzerland	G & S	Franc	.19,3
Tripoli	Silver	Mahbub of 20pias	.44,5
Turkey	Gold.	Piaster	.04,4
Venezuela	G & S	Boliviar	.19,3

MENSURATION.

TRIANGLES.

$\frac{\text{Base} \times \text{Altitude}}{2} = \text{Area}.$

$\frac{\text{Twice the Area}}{\text{Base.}} = \text{Altitude, or } \frac{\text{Twice the Area}}{\text{Altitude.}} = \text{Base.}$

Where the Altitude is not known, the following rule should be used, letting a, b and c represent the three sides of a triangle and s represent half their sum:

$\sqrt{S\,(S-a)(S-b)(S-c)} = \text{Area}.$

RECTANGLES AND SQUARES.

Length $\times$ Breadth = Area,

$\frac{\text{Area}}{\text{Length or Breadth.}} = \text{Breadth or Length.}$

Side $\sqrt{(\text{Diagonal}^2 - \text{Side.}^2)} = \text{Area}.$

CIRCLES.

Diameter $\times$ 3.1416 = Circumference.

Diameter$^2 \times .7854 = \text{Area}.$ $\qquad \sqrt{\frac{\text{Area}}{.7854}} = \text{Diameter}.$

$\frac{\text{Circumference}}{3.1416} = \text{Diameter}.$

ELLIPSE.

Long Diameter $\times$ Short Diameter $\times$ .7854 = Area.

SOLIDS.

Product of sides = volume of cube or rectangular parallelopiped.

Perimeter (circumference of base) $\times$ Altitude = surface of prism or cylinder.

Area of Base $\times$ Altitude = volume of prism or cylinder,

Circumference $\times$ Diameter = surface of sphere.

Diameter$^3 \times .5234 = \text{volume of sphere}.$

SHAFTING, BELTING, PULLEYS AND GEARS.

SHAFTING. The following rule for determining **size of shaft** for transmitting a given power at a given speed (8 ft. centres for hangers) is published by permission of William Sellers & Company, Makers of Tools, Shafting, etc., Philadelphia:

$$\sqrt[3]{\frac{\text{H. P.} \times 80}{\text{R. P. M.}}} = \text{diameter in inches.}$$

Where "H. P." = the horse power to be transmitted "R. P. M." = the revolutions per minute.

BELTS. The following is kindly furnished by William Hartley & Co., Makers of Leather Belting, etc., Pittsburgh, Pa., as a reliable rule for determining the **lengths of belting**:

$$\frac{(D + d \times 3.16)}{2} + 2\,D' = \text{Length.}$$

Where D = diameter of large pulley, d = diameter of small pulley, and D' = distance between centres of shafting.

PULLEYS AND GEARS. The following formulæ for determining the size and speed of **pulleys and gears** are kindly furnished by the Akron Iron Company, of Akron, Ohio:

$$\frac{\text{Driven} \times \text{r. p. m. of Driven.}}{\text{r. p. m. of Driver.}} = \text{Driver.}$$

$$\frac{\text{Driver} \times \text{r. p. m. of Driver.}}{\text{r. p m. of Driven.}} = \text{Driven.}$$

$$\frac{\text{Driven} \times \text{r. p. m. of Driven.}}{\text{Driver.}} = \text{r. p. m. of Driver.}$$

$$\frac{\text{Driver} \times \text{r. p. m. of Driver.}}{\text{Driven.}} = \text{r. p. m. of Driven.}$$

"r. p. m."=Revolutions per minute: "Driver"=Diameter of Driving Pulley. "Driven"=Diameter of Driven Pulley.

Driving and other extra heavy pulleys should always be located as near bearings as possible.

CONDUCTORS.

The **weight** and **resistance** per mile of round wire, where d is the diameter in mils, are:

	Weight.	Resistance at 75°.
For copper wire	$\frac{d^2}{62.5}$ lbs.	$\frac{56970}{d^2}$ ohms.
For iron wire	$\frac{d^2}{72}$ lbs.	$\frac{380060}{d^2}$ ohms.

Copper wire is approximately 1 1-7 times the weight of an iron wire of the same size.

A copper wire 334 circular mils in cross-section and 1,000 feet in length, weighs one pound.

The **percentage conductivity** of any wire is found by multiplying the resistance of a pure wire of the same length and weight at the same temperature (see table, page 161) by 100, and dividing the product by the resistance of the wire as measured.

The **resistance** of copper increases as the temperature rises, about .21 per cent. for each degree Fahrenheit, while that of iron increases about .39 per cent.

SPECIFIC INDUCTIVE CAPACITIES.

Dry air	1.
Ozite (Waring Compound)	1.80 to 2.16
Paraffine wax	1.92 to 2.47
Resin	2.55
India rubber, pure	2.34
" vulcanized	2.94
Shellac	2.95
Gutta percha	4.2
Mica	5.
Glass	6. to 10.

MELTING POINT, SPECIFIC GRAVITY AND RELATIVE CONDUCTIVITY.

ARTICLE.	Melting Point.	Specific Gravity	*Relative Conductivity.
Aluminium	1,160° F.	2.67	66.
Antimony	840 "	6.70	3.88
Bismuth	512 "	9.82	1.2
Brass.....about	1,869 "	8.4	22.
" Silicious (25 per cent. Zinc)			26.49
" (35 per cent. Zinc)			21.15
Bronze, Aluminium (10 per cent)			12.6
" Mercurial (Drosnier)			10.14
" Phosphor (10 per cent. Tin)			6.5
" Phosphor (Telephonic)			29.
" Silicium (Telegraphic)			98.
" " (Telephonic)			35.
" (20 per cent. Tin)			8.4
Copper, Pure	2,550° F.	8.889	100.
" " Crystallized			99.9
" and Silver Alloy (50 per cent.)			86.65
" Antimonous			12.7
" Arsenical (10 per cent. Arsenic)			9.1
" Plumbiferous (10 per cent. Lead)			30.
" Silicic (4 per cent. Silicon)			75.
German Silver	2,000° F.	8.5	5.8
Glass, Flint	2,377 "	2.90	
Gold	2,016 "	19.25	78.
Gold and Silver Alloy (50 per cent.)			16.12
Graphite			0.069
Gutta Percha	212° F.	0.98	
Iron, Cast.....average	2,786 "	7.12	
" Wrought	4,000 "	7.7	16.
Lead, Pure	630 "	11.4	8.88
Manganese.....about	3,000 "	8.01	
Mercury	—89. "	13.6	1.6
Nickel, Pure	2,800° F.	8.5	7.89
Ozite (Waring Compound)	250 "	1.25	
Paraffine	110 "	1.01	
Platinum, Pure	4,100 "	21.	10.6
Rubber, Pure	212 "	0.93	
Silver	1,873 "	10.74	100.
Tin, with 12 per cent. of Sodium			46.9
" Phosphide of			17.7
" Pure, of Banca	442° F.	7.3	15.45
Zinc, Pure	773 "	7.2	29.9

RULE.—To find the weight of any article, multiply its specific gravity by 62.4 lbs. (the weight of a cubic foot of water), or by .0361 lbs. (the weight of a cubic inch of water).

RULE.—To find pressure per square inch of water, multiply the height of column, in feet, by .43 lbs.

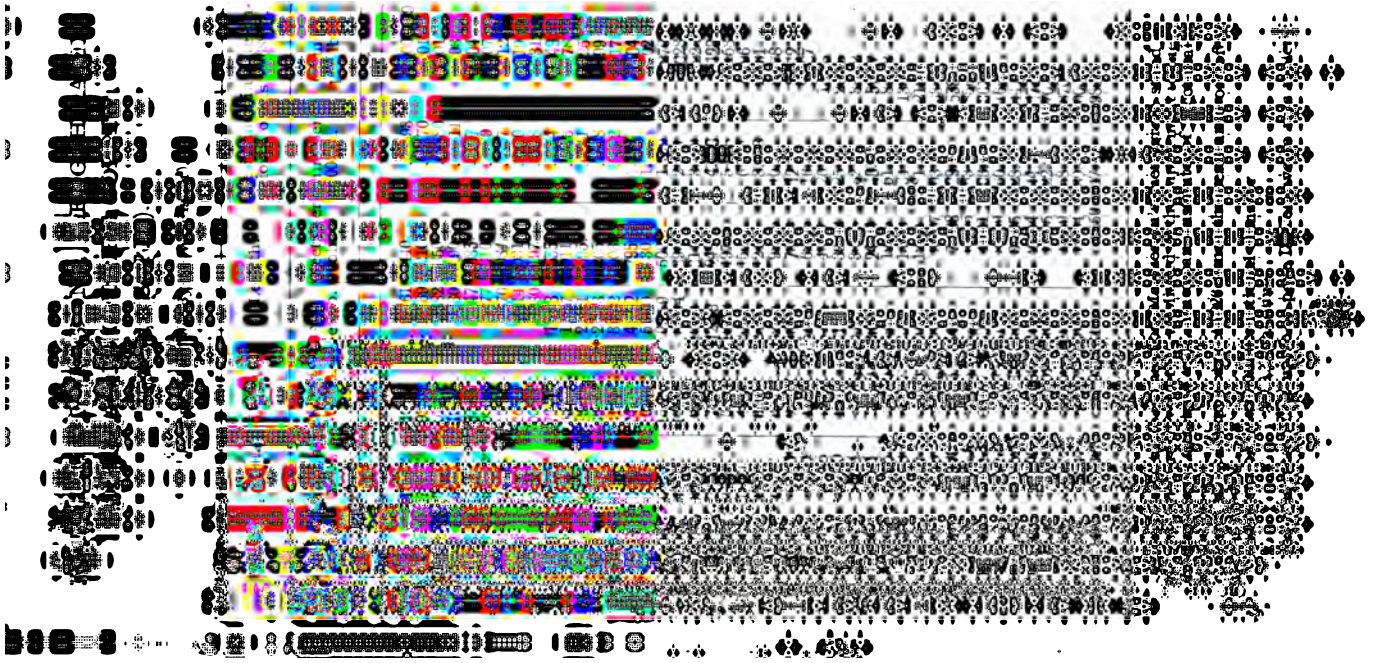
Pressure of the atmosphere is 14.7 lbs. to the square inch.

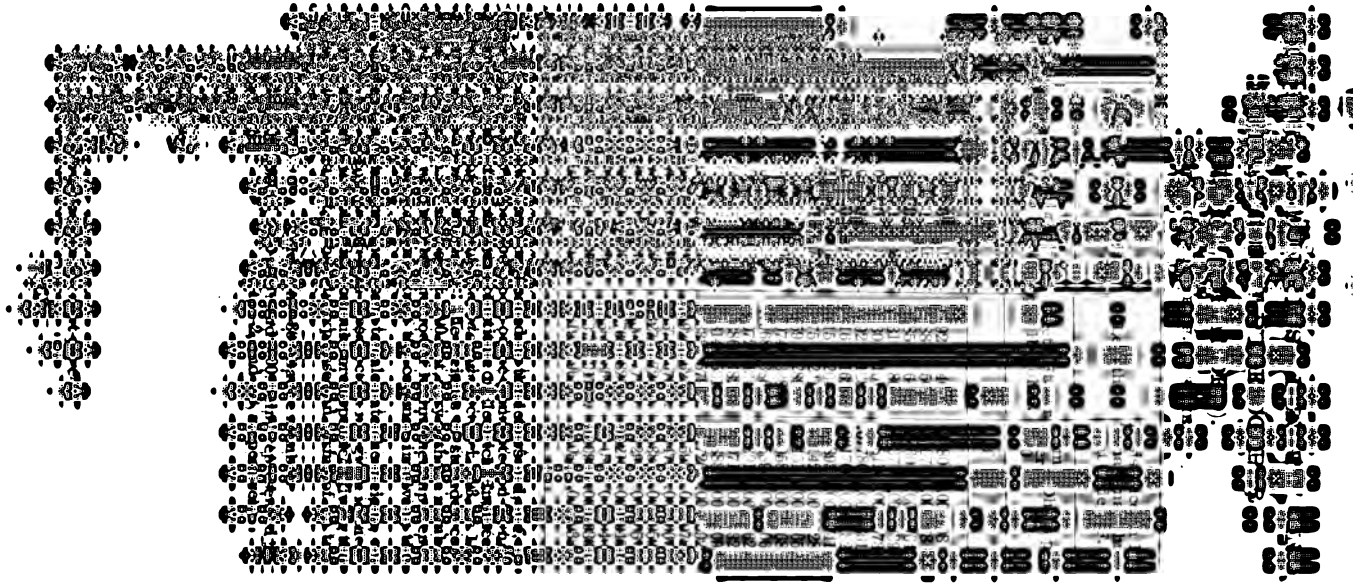
Pressure of one foot of water is .4333 lb. to the square inch.

*Most of these determinations of Relative Conductivity are by L. Weiller, in A. Watt's Electro Deposition of Metals, London.

TABLE COMPARING WIRE GAUGES.

No.	English (New British) Standard.		Brown and Sharpe.		Birmingham.		Old English.	
	Diameter	Wt. 1000 ft.	Diameter.	Wt. 1000 ft.	Diameter.	Wt 1000 ft.	Diameter.	Wt. 1000 ft.
0000	.400	484.88	.460	640.5	.454	624.58	.454	624.58
000..	.372	419.33	.40964	508.0	.425	547 33	.425	547.33
00....	.348	366.97	.36480	402.8	.380	437.56	.380	437.56
0.....	.324	318.10	.32495	319.5	.340	350.29	.340	350.29
1.....	.300	272.72	.28930	253.3	.300	272.72	.300	272.72
2.....	.276	230.83	.25763	200,9	.284	244,07	.284	244.07
3.....	.252	192.43	.22942	159.3	.259	208.27	.259	208.27
4.....	.232	163.09	.20431	126.4	.238	171.64	.238	171.64
5.....	.212	136.19	.18194	100.2	.220	146.66	.220	146.66
6.....	.192	111.71	.16202	79.46	.203	124.87	.203	124.87
7.....	.176	93.86	.14428	63.02	.180	98 18	.180	98.18
8.....	.160	77.57	.12849	49.98	.165	82.50	.165	82.50
9.....	.144	62.83	.11443	39.63	.148	66.37	.148	66.37
10.....	.128	49.65	.10189	31.43	.134	54.41	.134	54.41
11.....	.116	40.77	.09074	24.93	.120	43.63	.120	43.63
12.....	.104	32.77	.08081	19.77	.109	36.00	.109	36.00
13.....	.092	25.65	.07196	15.68	.095	27.35	.095	27.35
14.....	.080	19.39	.06408	12.43	.083	20.87	.083	20.87
15.....	.072	15.71	.05706	9.858	.072	15.71	.072	15.71
16.....	.064	12.41	.05082	7.818	.065	12.80	065	12.80
17.....	.056	9.60	.04525	6.200	.058	10.19	.058	10.19
18.....	.048	6.98	.04030	4.917	.049	7.27	.049	7.27
19.....	.040	4.85	.03589	3.899	.042	5.34	.040	5.34
20.....	.036	3.93	.03196	3.092	.035	3.71	.035	3.71
21.....	.032	3.10	.02846	2.452	.032	3.10	.0315	.....
22.....	.028	2.38	.025347	1.945	.028	2.88	.0295	.....
23.....	.024	1.74	.022571	1.542	.025	1.89	.027	.....
24.....	.022	1.47	.0201	1 223	.022	1.47	.025	.....
25.....	.020	1.21	.0179	.9698	.020	1.21	.023	.....
26.....	.018	.981	.01594	.7592	.018	.981	.0205	.....
27.....	.0164	.815	.014195	.6100	.016	.776	.01875	.....
28.....	.0148	.664	.012641	.4837	.014	.594	.0165	.....
29.....	.0136	.560	.011257	.3836	.013	.512	.0155	.....
30.....	.0124	.466	.010025	.3042	.012	.436	.01375	.....
31.....	.0116	.408	.008928	.2413	.010	.303	.01225	.....
32.....	.0108	.353	.00795	.1913	.009	.245	.01125	.....
33.....	.0100	.303	.00708	.1517	.008	.194	.01025	.....
34.....	.0092	.256	.0063	.1208	.007	.148	.0095	.....
35.....	.0084	.214	.00561	.09543	.005	.076	.009	.....
36.....	.0076	.175	.005	.07568	.004	.048	.0075	.....
37.....	.0068	.....	.00445	.06001	.....	.....	.0065	.....
38.....	.0060	.....	.003965	.04759	.....	.....	.00575	.....
39.....	.0052	.....	.003531	.03774	.....	.....	.005	.....
40.....	.0048	.....	.003144	.02993	.....	.....	.0045	.....





ILLUSTRATIVE EXAMPLES.

What is the resistance per 1000 feet of a conductor having a cross section 875,000 C. Mils?

Substituting in formula (f) we have $\frac{10854}{875000}$=.02761 ohms.

What is the weight per 1000 feet of No. 13 B. W. G. copper wire?

The cross section of the above=9025 C. M.

Hence we have C.=.0030269×9025=27.31 lbs.

CHANGE OF RESISTANCE WITH CHANGE OF TEMPERATURE.

Drs. Matthiessen and Siemen made elaborate measurements to determine the temperature co-efficient of copper wire, but the formulæ recommended by them are discordant, the difference becoming greater with increased temperature.

In 1890, Messrs. Kennelly and Fessenden by a most unique method in which the utmost care and precision were used, obtained a co-efficient which lies between the values obtained by Drs. Matthiessen and Siemen. On account of this fact, coupled with the well earned esteem as Physicists and Mathematicians, in which they are held both here and abroad, we recommend their formula for making corrections for change in resistance due to temperature.

Their formula reduced to degrees F. becomes

$$r=\frac{R(1+.00225\,(t-32))}{1+.00225\,(T-32)}.$$

When R=The known Resistance.

When r=The unknown Resistance.

When T=The temperature in degrees F. of known Resistance.

When t=The temperature in degrees F. of unknown Resistance.

For rough calculation it can be assumed that the variation in resistance amounts to .225% per degree F. increasing with rise, and decreasing with fall of temperature.

FORMULA FOR CALCULATING SIZE OF STREET RAILWAY FEEDERS.

A simple and convenient adaptation of the ordinary rule for determining the size of feeders, has been suggested by Mr. F. Uhlenhaut, Jr., late Electrical Engineer of the Philadelphia Traction Company, for quick work in figuring out sizes of street railway feeders. This formula is in brief:

Circular Mils=Car feet×6.5, being deduced from the formula,

$$\text{C. M.}=\frac{\text{Amperes}\times\text{Distance}\times 10.8}{\text{Volts lost}}$$

by the following assumptions and substitutions:

Amperes=Number of Cars×Amperes per Car.

Resistance 1 mil foot of wire=10.8 increased 20%=13.

Loss in volts=50. Amperes per car=25.

$$\text{Circular Mils}=\frac{\text{No. Cars}\times 25\times\text{Mean Distance}\times 13}{50}$$

C. M.=Car feet×6.5

WHEN IT IS NOON AT NEW YORK IT IS

11:06	A. M.	at Chicago, Ill.	6:06	P. M.	at Vienna, Austria.
10:56	"	" New Orleans, La.	5:50	"	" Rome, Italy.
9:56	"	" Denver, Col.	5:45	"	" Berlin, Prussia.
9:00	"	" San Francisco, Cal.	5:17	"	" Brussels, Belgium.
7:55	"	" Sitka, Alaska.	5:09	"	" Paris, France.
6:25	"	" Honolulu, S. I.	5:00	"	" London, England.
2:15	"	" Tokio, Japan.	4:45	"	" Madrid, Spain.
12:42	"	" Pekin, China.	4:35	"	" Dublin, Ireland.
9:47	P. M.	" Bombay, India.	2:36	"	" Pernambuco, Brazil.
7:02	"	" St. Petersburg, Rus.	1:25	"	" St. Johns, N. F.

ELECTRICAL UNITS AND FORMULÆ.*

All electrical units are derived from the following mechanical units:

The centimeter is the unit of length, and equals .3937 inch, or .000000001 of a quadrant of the earth.

The gram is the unit of mass, and is equal to 15.433 grains, the mass of a cubic centimeter of water at 4 ° C.

The second is the unit of time and is the time of one swing of a pendulum, swinging 86464.09 times per day, or the 1-86400th part of a mean solar day.

The **volt** is the unit of electro-motive force [E].

Electro-motive-force, which is the force that moves electricity, is usually written E. M. F. (in formulæ E) and various writers use it to express potential, difference of potential, electric pressure and electric force.

One volt will force an ampere of current through one ohm of resistance. Its value is purely arbitrary, but fixed.

The **ohm** is the unit of resistance [R].

The international ohm adopted by the International Congress of 1893 is represented by the resistance of a uniform column of mercury, 106.3 cms. long, and 14.4251 grammes in mass at a temperature of melting ice.

One B. A. ohm—.9866 International ohm.

One legal ohm—.9977 International ohm.

One ohm is that resistance through which one ampere of current will flow at a pressure of one volt of E. M. F.

The **megohm**—1,000,000 ohms.

The **ampere** is the unit of current strength [C]. Its value may be defined as that quantity of electricity which flows through one ohm of resistance when impelled by one volt of E. M. F.

One ampere of current flowing through a bath will deposit 0.017253 grain of silver or 0.005084 grain of copper per second.

The **coulomb** is the unit of quantity [Q], and is the quantity of electricity passing per second when the current is one ampere.

The **farad** is the unit of capacity [K], and is that capacity that will contain one coulomb at a potential of one volt.

A condenser of one farad capacity, if charged to two volts, will contain two coulombs, if to 100 volts, 100 coulombs, etc.

The **microfarad** [mfd],—one-millionth of a farad.

The **joule** is the unit of work [W]. It is the work done, or heat generated, by a watt in a second. It is equal to .7373 foot-pound.

The **watt** is the unit of electrical power [P], and is the energy contained in a current of one ampere with an electro-motive-force of one volt. 746 watts—one horse power. A current of 10 amperes, and 74.6 volts will do the work of one horse power

The E. M. F. is distributed according to the resistance of the various parts of the circuit, except where there is counter E. M. F.

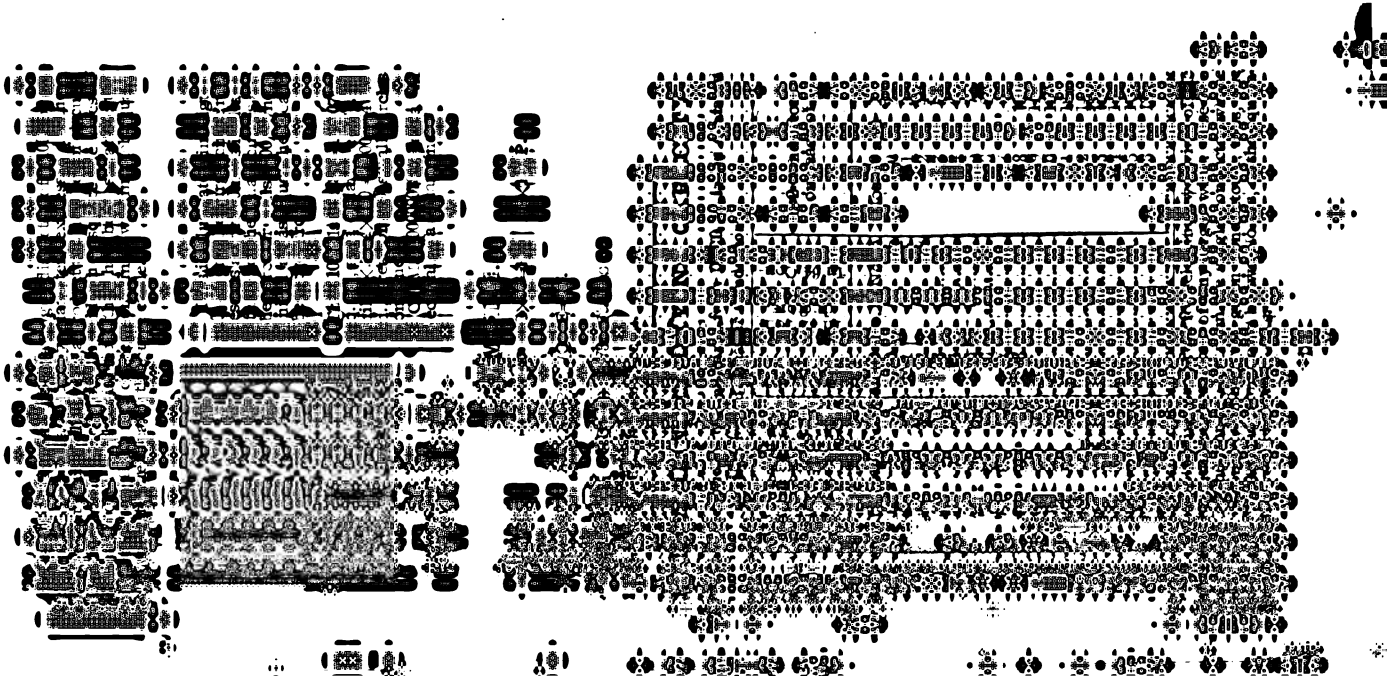
Counter E. M. F. is like back pressure in hydraulics. Thus, to find the available E. M. F., or the resulting current against a resistance where there is a counter E. M. F., the counter E. M. F. must be deducted. For example: Suppose a storage battery with a resistance of .02 ohm and a C. E. M. F. of 15 volts, and you wish to charge it with a dynamo which gives an E. M. F. of 20 volts at the battery binding posts; there are 20—15=5 volts working through a resistance of .02 of an ohm with consequently a current of 250 amperes. The fall of potential is, however, virtually 20 volts, and not 5 volts, and the power is 20×250=5,000 watts, and not 5×250=1,250 watts, as might perhaps be supposed. It is obvious that the C. E. M. F. has acted as a true resistance. In the above case 5×250=1,250 watts were wasted in overcoming the resistance of the storage battery; and the remaining 3,750 watts were stored up in the chemical changes which they brought about in the active material of the storage battery.

Mils—Thousandths of an inch.

d^2—**circular mils.**

The **circular mil** is now generally used as the unit of area when considering the cross-section of electric conductors, the resistance being inversely, and weight of copper directly, proportional to the circular mils.

*Portions of the Definitions of Electrical Units are from Memorandum Book of Modern Light and Heat, Boston, by courtesy of the publishers, and the author Mr. Allan V. Garrett, E. E., Spokane Falls, Washington.



RULES AND TABLES FOR WIRING.

The following rules and tables are based more particularly on using exposed wires, as distinguished from conductors in cables; owing to the higher temperature likely to be encountered underground, with consequent increase of their resistance, liberal allowance should be made in computing the areas of cable conductors, and the calculation should be checked by the tables and rules on pages 169, 170 and 171.

To compute the size of conductor required to supply any given number of incandescent lamps, where the amount of work done in the conductors is to be a certain percentage of the work done in the lamps—not a percentage of the total work of the machine:

When the lamps are in simple parallel, divide the resistance of one lamp (L) by the number of lamps (n) and multiply the result (R) by the percentage (%) it is intended to lose on the conductor; the product will be the resistance of the two conductors (r); divide by the total number of feet of conductor (*l*) (both sides of circuit), and multiply by 1,000. Then refer to table of resistances, page 161, and in the column headed "Ohms per 1,000 feet," find the nearest corresponding figures, and in the first column, same line, will be found the gauge of the conductor required.

Briefly: $\frac{L \times \% \times 1{,}000}{n \times l}$ = resistance per 1,000 feet.

When the lamps are in multiple series, the resistance of the lamps (R) will be found by multiplying the resistance of one lamp (L) by the number of lamps in each series, and dividing the product by the number of series.

RESISTANCE OF INCANDESCENT LAMPS.

	10	16	25	50	150	C. P.
Westinghouse, 50 volts.	71.5	50	33.3	16.6	5.5	ohms.
Edison, 100 volts	320	200	128	64	21.3	ohms.

The following Formulæ and Constants have been furnished by the Edison Co. as applying to their system:

Cir. Mils—Lamp feet × Constant.

Constant { 2-Wire System) = $\frac{21.68 \times (100 - \%\ \text{drop})}{\text{Resistance of lamp} \times \%\ \text{drop.}}$

3- " ") = $\frac{\text{2-Wire Constant}}{4}$

Thus: For the new 16 C. P. lamp (200 ohms resistance), on the three wire system, the following Constants would be used for the drop in E. M. F. indicated:

Volts.....	1.	1.5	2.	2.5	3.	3.5	4.	4.5	5.	6.	7.	8.	9.	10.
Const	2.68	1.78	1.34	1.07	.89	.76	.67	.60	.54	.45	.38	.33	.30	.27

SHORT RULES FOR DETERMINING SIZE OF CONDUCTOR.

$\frac{\text{Distance} \times \text{Amperes} \times 11^*}{\text{Loss in Volts}}$ = Circular Mils.

Or, in 50 Volt Work, 2% loss:
Distance × Amperes × 11 = Circular Mils.

If the work is at the end of the circuit, the factor "Distance" should be double the actual distance (or both sides of circuit), but if the work is evenly distributed it should be single distance only.

* 11 (ohms) is the resistance of a foot of copper wire one mil in diameter having a conductivity of 98 per cent. of that of chemically pure copper.

WIRING TABLE FOR 50 VOLT LAMPS. LOSS 1 VOLT—2 PER CENT. The Westinghouse Electric Co.

Amperes or 16 C. P. Lamps.	Distance in Feet to Centre of Distribution.								Wire Sizes are Indicated Below in B. & S. Gauge.							
	20′.	25′.	30′.	35′.	40′.	45′.	50′.	60′.	70′.	80′.	90′.	100′.	120′.	140′.	160′.	180′.	200′.
1.	16.	16.	16.	16.	16.	16.	16.	16.	16.	16.	16.	16.	16.	15.	14.	14.	13.
1.5	16.	16.	16.	16.	16.	16.	16.	16.	15.	15.	15.	14.	14.	13.	13.	12.	11.
2.	16.	16.	16.	16.	16.	16.	16.	16	15.	15.	14.	13.	13.	12.	12.	11.	10.
3.	16.	16.	16.	16.	16.	15.	15.	14.	13.	13.	12.	12.	11.	10.	10.	9.	9.
4.	16.	16.	16.	15.	15.	14.	13.	13.	12.	11.	11.	10.	10.	9.	8.	8.	7.
5.	16.	16.	15.	14.	13.	13.	13.	12.	11.	11.	10.	10.	9.	8.	8.	7.	7.
6.	16.	15.	14.	13.	13.	12.	12.	11.	11.	10.	10.	9.	8.	8.	7.	7.	6.
7.	15.	14.	13.	13.	12.	12.	11.	11.	10.	9.	9.	8.	8.	7.	6.	6.	5.
8	15.	14.	13.	12.	12.	11.	11.	10.	9.	9.	8.	8.	7.	6.	6.	5.	5.
9.	14.	13.	12	12.	11.	11.	10.	9.	9.	8.	8.	7.	6.	6.	5.	5.	4.
10.	14.	13.	12.	11.	11.	10.	10.	9.	8.	8.	7.	7.	6.	5	5.	4.	4.
12.	13.	12.	11.	11.	10.	10.	9.	8.	8.	7.	7.	6.	5.	5.	4.	4.	3.
14.	12.	11.	10.	10.	9.	9.	8.	7.	7.	6.	6.	5.	4.	4.	3.	3.	2.
16.	12.	11.	10.	9.	9.	8.	8.	7.	6.	6.	5.	5.	4.	3.	3.	2.	2.
18.	11.	10.	9.	9.	8.	7.	7.	6.	6.	5.	5.	4.	3.	3.	2.	2.	1.
20.	11.	10.	9.	8.	8.	7.	7.	6.	5.	5.	4.	4.	3.	2.	2	1.	1.
25.	10.	9.	8.	7.	7.	6.	6.	5.	4.	4.	3.	3.	2.	1.	1.	0.	0.
30.	9.	8.	7.	7.	6.	5.	5.	4.	3.	3.	2.	2.	1.	0	0.	0.	00.
35.	8.	7.	7.	6.	5.	5.	4.	4.	3.	2.	2.	1.	1	0.	00.	00.	000.
40.	8.	7.	6.	5.	5.	4.	4.	3	2.	2.	1.	1.	0.	00	000	000.	000.
45.	7.	6.	6.	5.	4.	4.	3.	2.	2.	1.	1.	0.	00.	00.	000	000.	0000.
50.	6.	6.	5.	4.	4.	3.	3.	2.	1.	1.	0.	0.	00.	000	000.	0000	0000.
55.	6	5.	5.	4.	3.	3.	2.	2.	1.	0.	0.	00.	00.	000.	0000.	0000.	0000.
60.	5.	5.	4.	4.	3.	3.	2.	1.	0.	0.	00.	00.	000.	000.	0000	0000.	
65	5.	5.	4.	3.	3.	2.	2.	1.	0	0	00.	00.	000	0000.	0000.		
70.	4.	4.	4.	3	2.	2.	1.	1	0	00.	00.	000.	000.	0000.	0000.		
75.	4.	4.	3.	3.	2.	1.	1.	0.	00.	00.	000.	000	0000.	0000.	.....		
80.	3.	3.	3.	2.	2.	1.	1.	0.	00.	00.	000.	000.	0000.	0000.	.....		
90.	3.	3.	2.	2.	1.	1.	0.	00.	00.	000.	000.	0000.	0000.	.....	.....		
100.	2.	2.	2.	1.	1.	0.	0.	00.	000.	000.	0000.	0000.	.....	.....	.. ....		

STANDARD LAMPS.

16 c. p. = 0.7 a.
16 " 1. "
25 " 1.5 "
50 " 3. "
150 " 9. "

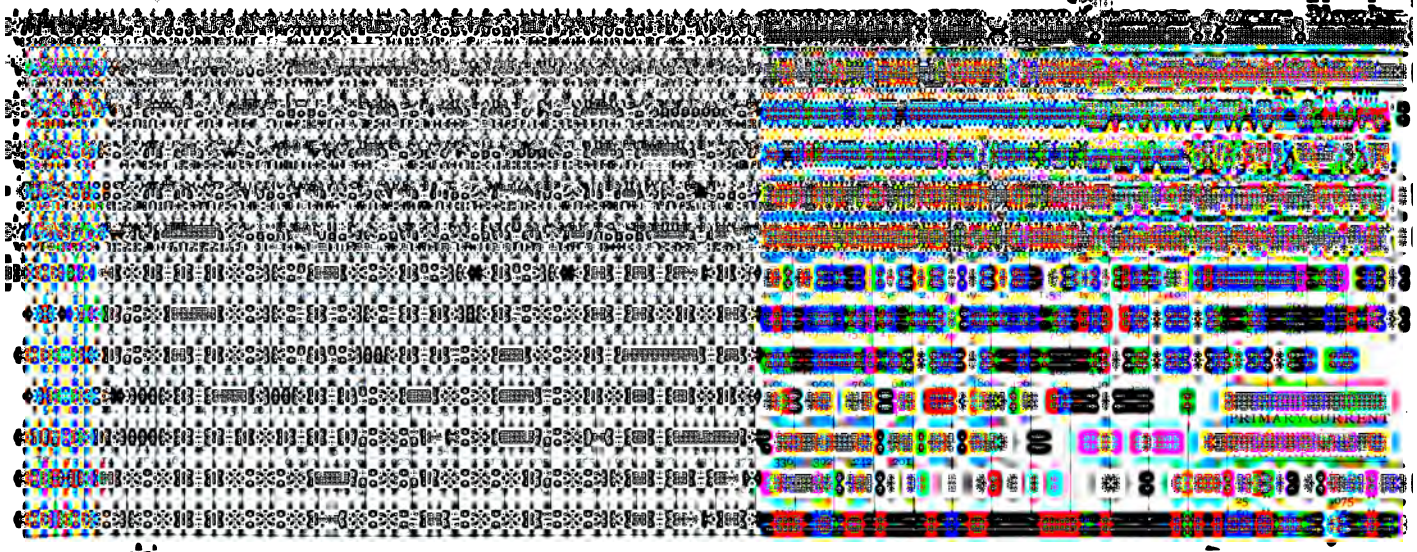
THE WESTINGHOUSE ELECTRIC CO.

ARC LIGHT WIRING TABLE.

(10 AMPERE CURRENT.)

Size of Wire. B. & S. Gauge.	Length (in feet) of Wire Equivalent in Resistance to one nominal 2000 c. p. Lamp.
No. 7	9,700
" 6	12,200
" 5	15,400
" 4	19,400

In case it should be desired to make up a circuit by using more than one conductor, see table of "Equivalent Carrying Capacity," on page 165.


PRIMARY CURRENT

CARRYING CAPACITY OF CABLES.

Prepared by Henry W. Fisher, Electrician of the Standard Underground Cable Co. Copyright, 1897.

Heating Effect in a piece of No. 0000 Cable. B. & S. G.		Factors for determining size of conductor, etc. (See Explanation below.)		Carrying Capacity S. U. C. Co's Cables Amperes 25° Rise.
Rise in temperature above the surrounding air. Degrees F.	Amperes required. (In Formulæ, A.)	Size Conductor. B. & S. G.	Factor. (In Formulæ, F.)	
2	84	10	.11	30
4	116	9	.13	36
6	138	8	.16	44
8	160	7	.19	52
10	**178**	**6**	**.23**	**63**
12	194	5	.27	74
14	208	4	.33	91
16	221	3	.39	107
18	234	2	.45	124
20	**246**	**1**	**.52**	**143**
22	258	0	.61	168
24	269	00	.71	195
26	280	000	.86	237
28	290	0000	1.00	275
30	**300**	**Cir. Mils.**		
32	309	250000	1.16	311
34	318	300000	1.29	355
36	326	350000	1.41	397
38	334	400000	1.55	438
40	**342**	**450000**	**1.71**	**477**
42	350	500000	1.85	515
44	358	550000	1.99	552
46	366	600000	2.15	589
48	373	650000	2.31	624
50	**380**	**700000**	**2.46**	**659**
52	387	750000	2.59	693
54	394	800000	2.72	726
56	401	850000	2.89	759
58	408	900000	3.02	791
60	**415**	**950000**	**3.15**	**823**
		1000000	3.28	854

The first and second columns are the result of a series of careful experiments made in our laboratory. The cable was placed on a wooden floor in the form of a large elliptical spiral of four turns, thus approximating to a condition that might occur in practice, viz: Four cables running side by side.

The table of factors (third and fourth columns) is the result of experiment and theory combined. Several tests were made on different sizes of cables laid as above described, in order to find the ratio between the amount of current necessary to raise them to a certain temperature and the amount of current required to raise the No. 0000 cable to the same temperature; then by the aid of theory and the curves that were drawn, the factors for the remaining sizes were obtained.

These tables serve for three purposes:

1st- To find what size conductor must be used for a given rise in temperature and a given number of amperes. Rule:

Decide upon some temperature that you consider safe, then divide the given number of amperes by the amperes corresponding to this temperature in the above table, compare the quotient thus obtained with the factors above and if no factor exactly agrees with the quotient, choose the size conductor corresponding to the next greater factor.

Briefly, letting A — the given number of amperes.

B — the amperes corresponding to the desired rise of temperature in the above table.

F — the factor for the size of conductor to be used.

Then $F=\frac{A}{B}$

Example:

With 14 degrees as a safe rise in temperature what size of conductor must be used to carry 175 amperes?

In the table we find 208 opposite 14 degrees; dividing 175 by this we have $\frac{175}{208}$=.84: Use No. 000.

2d—To find the number of amperes that will produce a given rise of temperature in any cable. Rule:

Multiply the amperes corresponding to said rise of temperature in the above table by the factor of the cable.

Briefly, using the same symbols as above: A=F×B.

Example:

How many amperes will produce a rise of 20 degrees in a piece of No. 3 cable? Opposite 20 degrees we find 246 amperes; multiplying this by .89, the factor for No. 3 cable, we have as the answer .89×246=96 amperes.

3rd—To find what rise of temperature will be produced in any cable by a given number of amperes. Rule:

Divide the amperes by the factor of the cable, and find the temperature corresponding to the quotient in the above table.

Briefly, $B=\frac{A}{F}$.

Example:

What temperature will be reached by passing 870 amperes through a cable having an area of 850,000 circular mils? $\frac{870}{2.89}$=301, and this corresponds to 80 degrees, which is the rise in temperature.

In choosing what shall be the safe temperature to which the cable shall be subjected, the condition and kind of subway should be considered. If the ducts are well ventilated, we would recommend 25 degrees F. as the maximum temperature to be used in making the calculations by the above method; while if the subway system is dry and poorly ventilated, we would not recommend a temperature exceeding ten or twelve degrees F. These varying values for the safe temperature are chosen on account of the difference in the dissipation of heat. In either case the actual temperature reached by the conductor would not be greater than 20 degrees above that of the earth, etc., adjacent to the cable, and this temperature is what we recommend as the one to be used in calculating the size of Aerial Cables. Very often the question of resistance, rigidity or strength makes it advisable or necessary to use larger cables than those obtained by calculation.

The above rules and tables apply to Electric Light Cables with 3-16 inch insulation between the conductor and the lead, but they may be considered approximately correct for any slight variation in thickness of insulation above or below this figure.

For the benefit of those familiar with the use of logarithms, who may desire to know something about the laws governing the rise of temperature, the following is appended:

Letting t = the rise of temperature in degrees F. above the surrounding air.

A = the number of amperes required to produce the rise of temperature.

K = a constant.

x = some unknown power to which A must be raised;

the form of the equation used was $t=\frac{A^x}{K.}$

By methods too elaborate to be mentioned here, the most probable value for x was found to be 2.1 and then the equation of the curve for No. 0000 Cable became $T=\frac{A^{2.1}}{5250.}$. In no place did this curve differ from the experimental curve by more than half of a degree. In the tests that followed on other cables of different sizes, the formula only differed from the above in the fact that the constants were different, and these constants are easily obtained from the formulæ, $K=5250\ F^{2.1}$, where F is the factor of any desired cable and K is its constant. Finally, the factors themselves can be calculated approximately through a range of from No. 10 to No. 0000 by means of the equation $F=\frac{C^{.7}}{5315}$ where C = the number of circular mils in the conductor and F = the factor of the conductor.

This formula departs a little from what theory would suggest as applied to solid conductors, the reason being that the relation existing between area and surface is not the same for stranded as for solid conductors.

TABLE COMPARING CARRYING CAPACITIES.

Size of Conductor				Maximum Amperes.			
B. & S. G. No.	Circular Mils.	Nearest Approximate B. W. G.	*Loss in Volts per Ampere per 1000 ft.	¶Theoretical, for Bare Cop'r Wire.	‖For Insulated Wire in Molding.	**For Electric Light Cables.	†For Bare Wire in the Abstract.
.....	500060	.....	.022	333.	348.	509	597.
.....	400000	.....	.028	282.	294.	426	489.
.....	850000	.....	.062	255.	265.	388	442.
.....	300000	.....	.087	227.	237.	345	394.
.....	250000	.....	.044	198.	207.	319	343.
0000	211600	000+	.062	174.6	182.7	275	302.9
000	167800	000½+	.065	146.7	153.5	237	254.5
00	133100	00½+	.083	123.3	129.0	195	213.9
0	105500	0½+	.104	103.7	108.5	168	179.8
1	83690	2+	.132	87.1	91.1	143	151.1
2	66370	3—	.166	73.2	76.6	124	127.0
3	52630	4—	.209	61.5	64.4	107	106.7
4	41740	6+	.264	51.7	54.1	91	89.7
5	33100	7—	.333	43.4	45.4	74	75.8
6	26250	8—	.419	36.5	38.2	63	63.3
7	20820	9—	.530	30.7	32.1	52	53.2
8	16510	10½+	.665	25.8	27.0	44	44.7
9	13090	11½—	.841	21.7	22.7	36	37.6
10	10380	12½+	1.061	18.2	19.1	30	31.6
11	8234	13½+	1.338	15.3	16.0	.....	26.5
12	6530	14—	1.687	12.9	13.5	.....	22.3
13	5178	15.	2.126	10.8	11.3	.....	18.7
14	4107	16—	2.682	9.1	9.5	.....	15.8
15	3257	17—	3.382	7.6	8.0	.....	13.2
16	2583	18+	4.264	6.4	6.7	.....	11.1
17	2048	18½+	5.396	5.4	5.6	.....	9.5
18	1624	19+	6.781	4.5	4.7	.....	7.9

*At 75° F. and for a wire of 98% conductivity. This column is also the resistance per 1,000 feet of the same wire in ohms.

¶This column was calculated from a theoretical formula based on Nicols' determination of the amount of heat lost by radiation and convection from blackened surfaces. Twenty degrees rise in temperature was assumed, the temperature of the surrounding air being taken at 90 degrees F.

The formula reduced to convenient form is $C=\frac{d^{\frac{3}{2}}}{56.5}$

Where d=the diameter of the conductor in mils,
C=the current in amperes.

This formula applies to solid conductors.

‖Calculated from a formula suggested by A. E. Kennelly, Electrical World, November 30th, 1889. Using the same symbols as above, the formula reduces to $C=\frac{d^{\frac{3}{2}}}{54}$. It is based on arise of temperature of about 19 degrees F.

**Calculated from the tables given on page 169 by the metho indicated in the directions for using the tables Twenty-five degrees was taken as the safe rise in temperature.

†Formula, $C=\frac{d^{\frac{3}{2}}}{32.56}$

This column represents the safe carrying capacity recommended by several companies; a comparison with the columns based on practical conditions will show how unsafe are these high figures. From a theoretical standpoint, they seem to be based on a rise in temperature of about 55 degrees, a practical application of which might be extremely disastrous, especially in warm weather or under conditions where the dissipation of heat is retarded.

ALTERNATING CURRENTS.

Owing to the extensive use of alternating currents in overhead feeders and underground electric cables it is thought necessary to give some formulæ and tables to be used in making calculations with reference to cables carrying alternating currents.

In the first place we shall give some general formulæ and later some results derived from practical tests.

For alternating currents Ohm's Law has the following form :

$$C=\frac{E}{\sqrt{R^2+P^2L^2}} \qquad (1)$$

where C=the current, E=the electromotive force, R=the ohmic resistance, P=2π times the frequency, and L=the "inductance" which depends upon the geometric form of the circuit and the magnetic properties of the conductors and the surrounding medium.

The expression $\sqrt{R^2+P^2L^2}$ is called the "Impedance." For a circuit consisting of two parallel wires each of a radius r, and having an inter-axial distance d, between them, the total length of the entire circuit being l feet,

$$L=\frac{80.48\ l(.5+4.6052\ \text{Log}\frac{d}{r})}{10^9}\ \text{Henrys} \qquad (2)$$

and for iron wire when the current density is low

$$L=\frac{80.48\ l(75+4.6052\ \text{Log}\frac{d}{r})}{10^9}\ \text{Henrys.}$$

The distance (d), and the radius (r), must be expressed in the same units of length.

The drop in voltage for an alternating current circuit $=C\sqrt{R^2+P^2L^2}$

SKIN EFFECT.

The alternating current causes an unequal distribution of the current in the wire, the current density decreasing towards the center of the conductor so that for large wires the central portion is useless as a conductor, thus increasing the resistance of the wire above that which it would be for a continuous current.

This is known as "Skin Effect."

The skin effect increases with the frequency and also with the diameter of the wire in such a way that for the same percentage of increase in the resistance due to skin effect the product [diameter^2×frequency] is constant.

This fact permits the following table to be constructed from which the increase in resistance may be calculated for a given frequency and size of conductor.

$\frac{(\text{Diameter})^2\times(\text{Frequency})=\text{Circular mils}}{1000000}\times\text{Frequency}$	Multiplying Factor.
25.0	1.02
35.0	1.04
43.0	1.06
49.5	1.08
56.5	1.10
71.5	1.15
84.5	1.20
96.0	1.25
108.0	1.30
130.5	1.40
154.5	1.50
178.5	1.60
204.0	1.70
232.5	1.80
268.5	1.90
294.	2.00

To find the factor with which the resistance to the direct current is to be multiplied, in order to obtain the resistance to the alternating currents, multiply the number of circular mils of the conductor by the frequency and divide by 1000000; then in the left hand column find between which two numbers the result lies. The required factor lies between the factors corresponding to these two numbers and is found by interpolation.

For example :—What is the resistance to the alternating curreut of an 850,000 circular mils conductor of which the resistance to the direct current is .001157 ohms, when the frequency is 133 alternations per second?

Here $\frac{\text{Circular mils}\times\text{Frequency}}{1000000}=.85\times133=113$

Referring to the table it is seen that this result lies between 108 and 130.5 and the difference between 108 and 130.5 is 22.5, which corresponds to a difference in the factor of 1.40,—1.80,=.10, and since the difference between 113 and 108 is 5 we have by simple proportion $.1\times\frac{5}{22.5}=.02$ as the increase in the factor above 1.80 corresponding to the increase in the numbers in the left hand column from 108 to 113, so that the factor corresponding to 113 is 1.80+.02=1.82.

Multiplying this by the resistance to the direct current we have .001157×1.82=.001527 ohms as the resistance to the alternating current.

NOTE.—The above method is based on Lord Kelvin's calculations for solid conductors and we believe that for *practical* purposes it can be applied with sufficient accuracy for conductors composed of stranded wires.

Illustrative example for the calculation of the alternating currents.

What is the current flowing in an 850,000 circular mil stranded conductor 95 feet long the circuit consisting of two parallel conductors, with an inter-axial distance of 4 inches, when the impressed E. M. F.=3.73 volts and the periodicity 133.

Here the diameter of conductor=1094 mils.

The resistance to the direct current=.001157 ohms, therefore the resistance to the alternating current=.001527 ohms.

(See example under skin effect).

The inductance (L) is found from formulæ (2)

$$L=\frac{80.48\times 95(.5+4.6052\ \text{Log}\ \frac{4000}{547})}{10^9}=\frac{12972}{10^9}\ \text{Henrys}$$

Substituting in equation (1) this value for (L), and also the value of P, R, and E we have

$$C=\frac{3.73}{\sqrt{(.001527)^2+\left(\frac{2\times 3.1416\times 133\times 12972}{10^9}\right)^2}}=\frac{3.73}{.01095}=340\ \text{Amperes.}$$

In an actual test in which the above conditions were approximately fulfilled the current by actual measurement was 334 amperes.

In this case where the centers of the conductors were 4 inches apart it will be seen that the impedance was $\frac{.01095}{.001527}=7.2$ times the ohmic resistance.

On reducing the inter-axial distance to 8 inches the result of an actual test gave the impedance to be about 6.6 times the ohmic resistance; and upon bringing the two branches of the circuits so close together that the lead coverings almost touched, the impedance was reduced to about 5.5 times the ohmic resistance.

The results of these tests as well as theory clearly show the advantage of placing the two branches of an alternating circuit as near together as possible.

This is best accomplished in the Duplex Cable and an actual test has shown that in a piece of 00 Duplex Cable the impedance was only about 1.5 times the ohmic resistance.

HEATING EFFECT OF THE ALTERNATING CURRENT.

For the same current a cable will become more heated when the current is alternating than when it is direct.

This is most marked with large conductors owing to the skin effect. There may even be in the interior of the conductor a current reverse in direction to that nearer the surface.

In an alternating circuit composed of two separate cables the lead covers of which were touching at frequent intervals, as is often the case in practice, the rise of the cable in temperature above the surrounding air, was found by an actual test to be nearly double what it was when the lead coverings were insulated from each other.

This is due to induced currents in the lead, which short circuit themselves at the points of contact of the lead covers.

With a short length of cable we have obtained as much as 180 amperes between the lead of one cable and that of the other.

Sparks between the lead covers of single cables conveying alternating currents have frequently been observed in manholes and the cause of gas explosions in these manholes has been attributed to this phenomenon.

the electrical qualities of some of the various kinds of insulating mediums employed by us.

It is a well-known fact that a slight variation in the quality and amount of insulating material used in the construction of a cable, may make quite a difference in the insulation and capacity, and hence other cables, of nominally the same insulating material and dimensions as above, may give, under varying temperatures, somewhat different results.

DESCRIPTION OF CABLES.

("a") represents a Telephone Cable in which strips of paper are wound spirally and loosely around the wire. The main object in so doing is to enclose as much air as possible and thus ensure a low Electrostatic capacity.

("b") represents an Electric Light Cable insulated with jute and hard Ozite. The insulation resistance of this class of cable is high but owing to the hardness of the compound we do not use it on all sizes of cables, nor do we recommend laying such a cable in very cold weather.

("c") represents a fibrous Electric Light Cable insulated with soft Ozite. The insulation resistance is lower than that of "b" but on account of the oily nature of the compound this cable withstands breakdown strains from high voltage just as well as "b," and and it can be laid in cold weather without danger of breaking the insulation and fiber when the cable is bent.

("d") and ("e") represent cables insulated with our Sterling Rubber Compound, taped and provided with a lead cover, the compound being vulcanized in the ordinary manner; it can however, be vulcanized by a special method so as to greatly increase the insulation resistance and decrease the electrostatic capacity.

To determine the Insulation, Resistance, and Electrostatic Capacity from the dimensions of the cable the following formulæ may be used.

$$\text{Insulation resistance per mile in megohms} = k \operatorname{Log}\frac{D}{d} \qquad (1)$$

$$\text{Electrostatic Capacity per mile in microfarads} = \frac{c}{\operatorname{Log}\frac{D}{d}} \qquad (2)$$

Where D=Outside Diameter over Insulation.
d=Diameter of Conductor.
k=A constant depending upon the insulating material and temperature.
c=A constant depending upon the insulating material and temperature.
"D" and "d" must be measured in the same units of length.

ILLUSTRATIVE EXAMPLE.

What would be the Insulation Resistance per mile at 70° F. of a No. 6 B. & S. G. cable insulated to $\frac{5}{32}$ inch, with the same compounds as used in cable (c)?

For Cable (c) at 70 degrees.

Insulation resistance per mile=400 Meghoms.

$$d = \frac{23}{64}$$

$$D = \frac{23}{64} + \frac{23}{64} - \frac{52}{64}$$

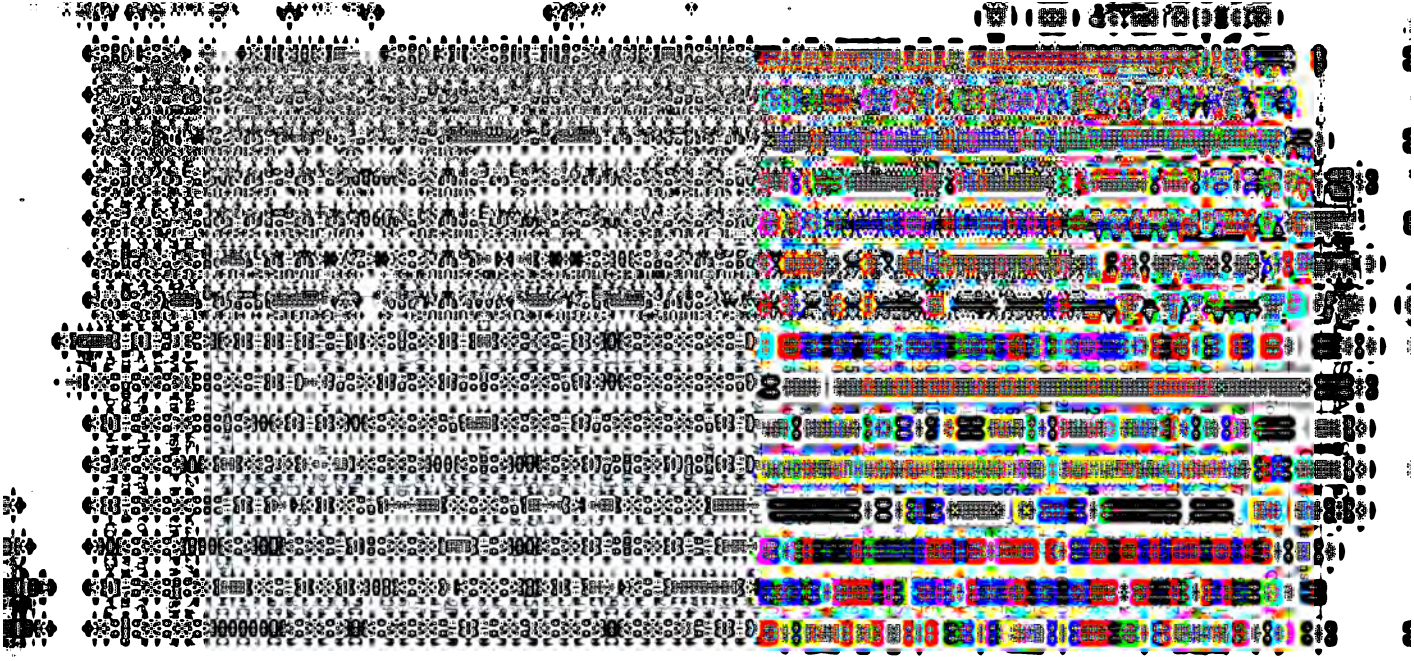
From this data the value of k is found by substituting in the formulæ and solving for k.

Thus

$$k = \frac{400}{\operatorname{Log}\frac{52}{64}} = \frac{400}{\operatorname{Log} 1.6858} = \frac{400}{.2268} = 1760$$

Then by using this value of k and substituting for D and d their dimensions in the cable of which the insulation Resistance is to be determined, we have insulation resistance per mile of No. 6 B. & S. G. insulated to $\frac{5}{32}$ = $k \log\frac{D}{d} = 1760 \operatorname{Log}\frac{.162+.375}{.162} = 916$ megohms per mile.

The capacity Constant "c" for any given material and temperature can be determined from formula (2) by the same method as was used above to determine "k" from formulæ (1) and then the Capacity per mile for any cable of the same material can be found by substituting in formula (2) the dimensions of the cable (D and d) and the value found for constant "c."



TELEPHONE STATISTICS.

AMERICAN BELL TELEPHONE COMPANY.

	JAN. 1st., 1896.	INCREASE OVER 1895.
Number of Exchanges	927	60
Number of Branch Offices	686	114
Instruments Under Rental	674,976	92,470
Miles of Wire on Poles	260,824	28,816
Miles of Wire on Buildings	12,861	1,664
Miles of Wire Underground	184,515	36,280
Miles of Wire Submarine	2,028	172
Total Miles of Wire	459,728	68,054
Total Circuits	237,837	25,768
Total Employees	11,980	886
Total Stations	281,695	38,268
TOLL LINES.		
Miles of Pole Lines	52,878	3,549
Miles of Wire	215,687	35,180
Estimated Daily Exchange Connections	2,351,420	
Estimated Yearly Exchange Connections	757,000,000	
Average Daily Toll Connections.	51,128	
Average Yearly Toll Connections	16,400,000	

The longest distance over which conversations are maintained is 1,625 miles, from Boston, Mass., to Memphis, Tenn.

OTHER TELEPHONE COMPANIES.

Telephone Companies other than the American Bell, are rapidly being organized throughout the country in very large numbers.

At the present time, however, there is no very definite information extant as to the number and equipment of such companies, and we do not give any statistics, as they would only be misleading.

COMPARATIVE COST PER MILE OF OVERHEAD WIRES AND CABLES.

(85 POLES TO THE MILE.)

Overhead Wires Bare, Materials, etc.	50 Wire Line 40 Foot Poles.	100 Wire Line. 45 Foot Poles.	200 Wire Line 60 Foot Poles.
Poles, Cedar	$ 181.25	$ 166.25	$ 455.00
Poles, Setting	28.00	31.50	44.00
Cross-Arms, (10 pins)	61.25	122.50	245.00
Cross-Arms, attaching to poles	17.50	35.00	70.00
Braces and Screws	.60	1.20	2.40
Pins, (1½ inch Locust)	17.50	35.00	70.00
Pins, attaching to arms	2.60	5.20	10.40
Insulators	21.00	42.00	84.00
Insulators, attaching to pins	1.50	3.00	6.00
No. 14 B. & S. G. Hard Drawn Copper Wire	497.96	995.92	1,987.84
Labor Stringing Wire	200.00	380.00	740.00
Total	$ 979.16	$1,817.57	$3,708.64
LEAD COVERED AERIAL CABLE.			
Thirty-five Poles (30 feet)	$ 52.50	$ 52.50	$ 52.50
Labor, Setting	24.50	24.50	24.50
One Mile Galvanized Strand	20.59	20.59	51.22
Stringing Same, Including Supports	52.00	52.00	52.00
One Mile New Standard Cable and Installing Same Complete	1,214.40	1,686 80	2,428.80
Total	$1,363.99	$1,786.89	$2,609.02

The prices of various materials used in the foregoing estimate are the average prices paid in various portions of the country, and are very closely approximate for the *average* conditions.

We have compiled the following table, showing the cost of installing 25 pairs, 50 pairs, and 100 pairs underground cable, No. 19 B. & S. G., dry paper insulation, complete and ready for service, in conduits of three different types, these costs including also the cost of conduit and installation of same complete, under average conditions.

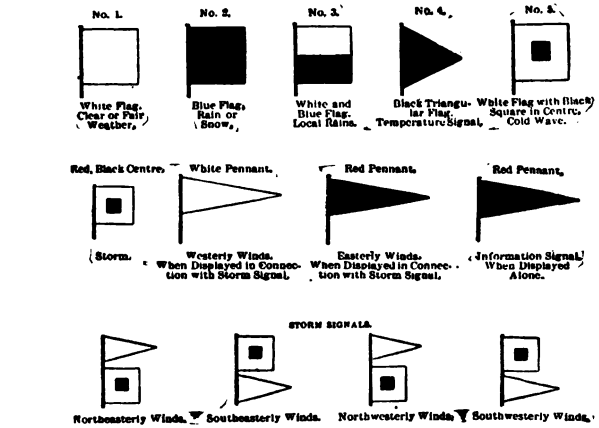
It should be remembered in comparing these costs that an additional duct could be laid at the time of making the original installation at an increased average cost of about 20 cents per foot, which will thereby render it possible to double the capacity of the system at any time that it may be necessary, with only the slight increase entailed in the cost of the cable itself, and its installation; whereas, in order to duplicate the original system of bare wires on poles, the entire original cost of the overhead system will be again incurred.

COMPARATIVE TABLE.—Costs of Various Systems.

STYLE OF SYSTEM.	50 WIRES.	100 WIRES.	200 WIRES.
Bare Wire, No. 14 Copper	$ 979.16	$ 1,817.57	$ 3,708.64
Aerial Lead Covered Cable, No. 20 B. & S. G.	1,363.99	1,786.89	2,609.02
Underground Cable, No. 19 B. & S. G. in creosoted wood conduit	2,217.60	2,640.00	3,484.80
In hollow brick tile	2,376.00	2,798.40	3,643.20
In cement lined pipe	2,640.00	3,062.80	3,907.60

When it is considered in connection with these figures, that the relative yearly cost of maintenance of overhead wires, and overhead and underground cables, is tremendously in favor of cables, namely, about 10 per cent. for overhead wires, and from nothing to not over ½ of 1 per cent. for cables, the advisability of using cables becomes clearly manifest.

WEATHER SIGNALS.


No. 1.
No. 2.
No. 3.
No. 4.
No. 5.
White Flag, Clear or Fair Weather.
Blue Flag, Rain or Snow.
White and Blue Flag. Local Rains.
Black Triangular Flag. Temperature Signal.
White Flag with Black Square in Centre. Cold Wave.
Red, Black Centre. Storm.
White Pennant. Westerly Winds. When Displayed in Connection with Storm Signal.
Red Pennant. Easterly Winds. When Displayed in Connection with Storm Signal.
Red Pennant. Information Signal. When Displayed Alone.
STORM SIGNALS.
Northeasterly Winds.
Southeasterly Winds.
Northwesterly Winds.
Southwesterly Winds.

No. 1, white flag, six feet square, indicates clear or fair weather. No. 2, blue flag, six feet square, indicates rain or snow. No. 3, white and blue flag, (parallel bars of white and blue), six feet square, indicates that local rains or showers, will occur, and that the rainfall will not be general. No. 4, black triangular flag, four feet at the base and six feet in length, always refers to temperature, when placed above Nos. 1, 2 or 3 it indicates warmer weather; when placed below Nos. 1, 2 or 3 it indicates colder weather, when not displayed the indications are that the temperature will remain stationary, or that the change in temperature will not vary more than five degrees from the temperature of the same hour of the preceding day from June to August, inclusive, seven degrees from November to March, inclusive, and not more than six degrees for the remaining months of the year.

No. 5, white flag, six feet square, with black square in center, indicates the approach of a sudden and decided fall in temperature, and is usually ordered at least twenty-four hours in advance of the cold wave. When No. 5 is displayed, No. 4 is always omitted.

A special storm flag, red with black square in center, is prescribed for use in North and South Dakota, Minnesota, (except at Lake stations), Iowa, Nebraska and Wyoming to indicate high winds, accompanied by snow, with temperature below freezing.

When displayed on poles, the signals should be arranged to read downward; when displayed from horizontal supports, a small streamer should be attached to indicate the point from which the signals are to be read.

No. 1 alone, indicates fair weather, stationary temperature.

No. 2 alone, indicates rain or snow, stationary temperature.

No. 3 alone, indicates local rain, stationary temperature.

No. 1 with No. 4 above it, indicates fair weather, warmer.

No. 1 with No. 4 below it, indicates fair weather, colder.

No. 2 with No. 4 above it, indicates warmer weather, rain or snow.

A Storm Signal. A red flag with black center indicates that the storm is expected to be of marked violence.

A Red Pennant displayed with the flags indicates easterly winds—that is from northeast to south, inclusive, and that the storm center is approaching.

A White Pennant displayed with the flags indicates westerly winds—that is from north to southwest, inclusive, and that the storm center has passed.

When the Red Pennant is hoisted above the storm signals, winds are expected from the northwest quadrant, when below, from the southeast quadrant.

When the White Pennant is hoisted above the storm signal, winds are expected from the northwest quadrant, when below from the southwest quadrant.

NIGHT SIGNALS.—By night a red light will indicate easterly winds, a white light above a red light will indicate westerly winds.

The Hurricane Signal consists of two red flags with black centers, displayed one above the other, and will be used to announce the expected approach of tropical hurricanes and also of those extremely severe and dangerous storms which occasionally move across the Lakes and the Northern Atlantic coast.

Identification.

MY NAME IS

.....

MY ADDRESS IS

.....

.....

In Case of Accident or Serious Illness Please Notify

.....

.....

.....

Reminders.

The No. on the Case of my Watch is.....

The No. on the Works is.....

My Weight was.....

and My Height.....Feet.....Inches,

on.....189.....

Size of my Collar.....

Size of my Cuffs.....

Size of my Gloves.....

Size of my Hat.....

Size of my Hosiery.....

Size of my Shoes.....

.....